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VOL. 20 APRIL, 1927 NO. 2

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

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PUBLISHED BY
AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
GENEVA, N. Y.

Entered March 14, 1921, as second-class matter at the Post-Office at Geneva, N. Y., under the Act of Congress of March 3, 1879

JOURNAL
OF
ECONOMIC ENTOMOLOGY
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Proceedings of the Thirty-Ninth Annual Meeting of the American Association of Economic Entomologists (*Cont.*)

Friday Morning Session, December 31, 9:45

PRESIDENT ARTHUR GIBSON: The first paper on the program this morning is by W. S. Regan.

RELATIVE VALUE OF DIFFERENT INSECTICIDE TREATMENTS FOR THE CONTROL OF CODLING MOTH IN THE PACIFIC NORTHWEST

By W. S. REGAN, *Research Department, California Spray-Chemical Co., Yakima, Washington*

ABSTRACT

There is much difference of opinion on the part of both investigators and practical orchardists as to the most effective and economical control for codling moth, *Carpocapsa pomonella* Linn. The best dosage of Arsenate of lead to use, the advantage of spreader, the value or necessity of a calyx spray, the advisability of dependence on spray dates, the use of oil spray as an ovicide, the factor of thoroughness and the effect of various spray treatments on the removal of spray residue by wiping etc., are all matters over which there is a wide diversity of opinion. The results of numerous tests and observations are given as further evidence in favor or against the matters at issue.

[Published in full by the California Spray Chemical Company, Watsonville, Calif.]

MR. W. P. FLINT: One matter that came up in connection with some of our work with oil sprays in Illinois might be of interest in some other sections. In spraying a block of mature Ben Davis trees with oil throughout the season, except that the regular lead calyx spray was given, we had forty-two per cent worms on the oil sprayed block against about sixteen on the arsenate of lead sprayed block, but the point that I wanted to bring out was the oil sprayed block had 45.9 per cent of the apples injured by a little beetle, *Metachroma interruptum* Lec., that was

reported at the Cincinnati meeting, and which gouged the surface of the fruit much the same way as the Japanese beetle does, only it is a smaller insect. That was a totally unexpected type of injury that occurred.

MR. P. J. PARROTT: I would like to ask Mr. Regan if he could briefly tell us the results of any experiment with the codling moth where the oil alone was used, and what would be the number of applications to get efficient control?

MR. W. S. REGAN: In the Northwest this season there were a number of growers who for their own information carried out a State oil program. I know a number of growers who used it on apples. Several growers used it on pears. I can give you one case where a grower sprayed three times with one and a half per cent of the oil of Ortho-K. He sprayed four times with lead, and four times with the lead and oil combined on different blocks in the same orchard. Where he used the oil alone, with three applications, he had eight per cent culls due to worms. Where he had used the arsenate of lead alone, he had six per cent with four applications. Where he used the arsenate of lead and oil combined, he had two per cent.

Most of these growers who used the oil alone seemed to think that they had pretty fair results. On pears that worked out very satisfactorily. There were none of the unfavorable reactions on pears that we found on some varieties of apples. I would say that five applications would be the limit needed under our conditions.

PRESIDENT ARTHUR GIBSON: The next is a paper by C. R. Cutright.

PARADICHLOROBENZENE AGAINST THE BLACK PEACH APHIS, *ANURAPHIS PERSICAE-NIGER* SMITH

By C. R. CUTRIGHT, *Ohio Agricultural Experiment Station, Wooster, O.*

ABSTRACT

The results of four years field experimentation show that Paradichlorobenzene can be used safely and effectively.

The chief commercial peach growing section in Ohio is located along Lake Erie about fifty miles east of Toledo. In this section much of the land has been in peach orchards for from thirty to forty years continuously. On lands such as these, and particularly on sandy, gravelly, or stony areas, great difficulty is now experienced in successfully starting a new orchard. Several years ago attention was drawn to this condition by growers who claimed that the death of the newly planted trees was due to the black peach aphis attacking the roots. In this section of Ohio an aerial colony of this aphid is rarely seen.

The insect is subterranean in habitat and is zealously cared for by an ant, *Lasius umbratus*, subsp. *mixus*, var., *aphidicola* Walsh. Upon examination it was found that the roots of most of the dying trees were infested with aphids in more or less numbers. Since this was the case it was only logical to suppose that they were at least a factor in the death of the trees and experiments looking forward to their control were arranged.

During the summers of 1923–24 a large number of insecticides and repellents were applied about the roots of newly set peach trees. The materials used, the amounts, the method and time of application have been reported in Ohio Bulletin No. 387. Of all these materials Paradichlorobenzene, applied as for the peach tree borer, alone gave definite results.

The condition that we presumed was caused by the aphids became apparent each season about the middle of June. It consisted in the

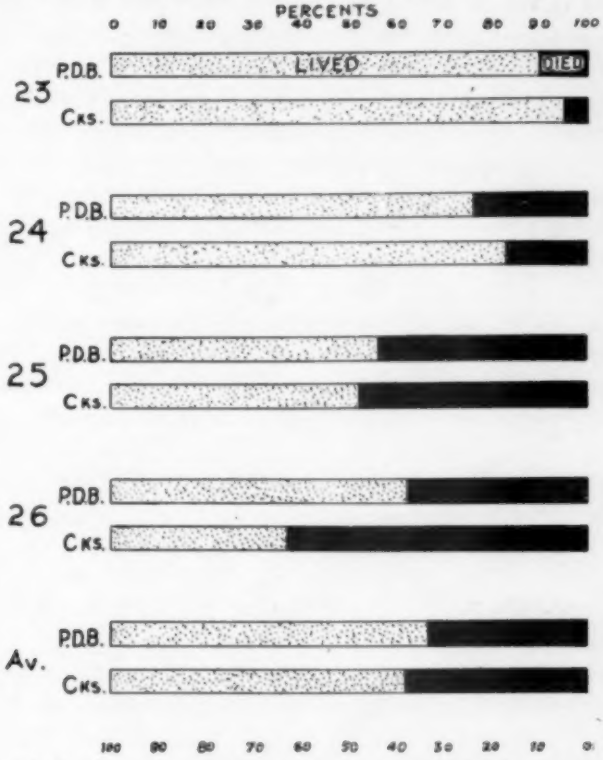

Fig. 11—Survival of peach trees treated with paradichlorobenzene as compared with untreated trees.

cessation of growth, the wilting and withering of the leaves, and finally in the death of the tree. It was considered that the logical time to apply a preventative treatment would be just before or at the first appearance of the signs of injury. However the treatment of trees with Paradichlorobenzene for the control of the peach tree borer is practically never made at this season of the year nor is it applied to trees so soon after planting. Aside from the results to be obtained in aphid control the effect that the material might have on the trees was of much interest and data was collected on this point during a four-year period (Fig. 11). In 1923 thirty trees were treated with Paradichlorobenzene in amounts ranging from 1/6 to 1/2 ounce per tree. Three of these trees or ten per cent died or were very weak at the end of the growing season. Twenty untreated trees were used as checks and one of these or five per cent died. In 1924 fifty-five trees were treated, using from 1/4 to 3/4 ounce. Of these, thirteen trees or twenty-four per cent died. There were seventy check trees, of which twelve or seventeen per cent died. In this year it was noticed that there was a somewhat higher per cent of mortality among the trees treated with 1/2 to 3/4 ounces of the material. In 1925 there were 105 treated trees. Of these, forty-six or forty-four per cent died. We had forty-nine check trees and twenty-three of these or forty-seven per cent died. In 1926 there were thirty-one treated trees, of which twelve or thirty-eight per cent died. On thirty-eight check trees, twenty-four or sixty-three per cent did not live through the season. From the totals of the four-year period 33.4% of the treated trees died, while 38.2% of the check trees succumbed. Since the date of our earliest planting in 1923 I have failed to see in following years any difference in growth between the treated and the check trees. There is little to indicate that Paradichlorobenzene in 1/4 or 1/3 ounce doses injures the tree when applied under the conditions of these experiments. It is of interest to note that the seasons of 1923–24 were favorable to tree growth, with much rain in June and July. In 1925–26 little rain fell during this important period.

As to the effect of Paradichlorobenzene on the aphids, the results can be briefly summarized as follows: Of all the trees treated with this material that have been examined only one has been found that was infested, and it very lightly. Many of the check trees were infested by aphids in considerable numbers. The Paradichlorobenzene as applied in these experiments seemed to act quite definitely as a repellent against the ants. When applied directly against the aphids on trees that were known to be heavily infested, large numbers of the lice were killed.

Considering the foregoing results which were obtained over a four-year period of time and in which about 500 trees were involved, we may safely conclude that Paradichlorobenzene is a safe and effective remedy for the black peach aphis.

However, there yet remains another phase of this problem to be discussed; namely, in spite of the control of the aphids the newly set trees continue to die. During the first year of work we began to doubt if the aphis was really the cause of the trouble and since that time a definite conclusion of this nature has been reached. The following observations led to this belief. Each year many dying trees were examined on which no aphids could be found, or the aphids were so few in number as to preclude the idea of their being the cause of the injury. Young trees were also planted on other types of soil that had not previously grown peaches and were artificially infested to a much greater degree than anything found in the experimental plots. In spite of this severe infestation these trees grew normally. Therefore, the death of the newly set trees is not due to the black peach aphis but is caused by some other agency. This is undoubtedly outside the field of economic entomology and its determination and solution must be attempted by specialists in other lines of work.

PRESIDENT ARTHUR GIBSON: The next paper is by J. R. Eyer.

TESTS OF SOME RECENTLY DEVELOPED INSECTICIDES IN CONTROL OF THE GRAPE LEAFHOPPER AND ORIENTAL FRUIT MOTH

By J. R. EYER, *North East, Pa.*

ABSTRACT

Certain of the more recently developed insecticides including emulsions of pyrethrum, derris, coconut fatty acids, orthotoluidine, wormseed oil, and carbon disulphide were tested in comparison with nicotine sulfate and sodium fluosilicate, colloidal arsenate of lead, and coated arsenate of lead in comparison with dry arsenate of lead. Early in the season the emulsions, and sodium fluosilicate were sprayed on the nymphs and on foliage containing eggs of the grape leafhopper (*Typhlocyba comes* Say). Pyrethrum soap emulsion killed the nymphs equally as well as nicotine sulfate and prevented the hatching of eggs. Derrisol also killed the nymphs but was not so effective as an ovicide. Sodium fluosilicate killed the nymphs but burned grape foliage unless combined with hydrated lime or Bordeaux mixture. Combinations of these materials with Bordeaux mixture did not seem to affect their toxicity to leafhopper nymphs.

Later in the season twigs containing larvae of the oriental fruit moth (*Laspeyresia molesta* Busck), were sprayed with the emulsions mentioned and although no killing

resulted it was observed that the younger larvae which left twigs sprayed with pyrethrum soap emulsion were stunned and unable to re-enter. Further tests with this material were made in the laboratory using sprayed peaches and larvae of graded sizes. When combined with sodium fluosilicate and Bordeaux mixture this insecticide was very effective in preventing larvae from entering the fruit. A dust of pyrethrum powder, hydrated lime, and sodium fluosilicate was also quite effective and sodium fluosilicate combined with hydrated lime and used as a spray or dust killed a large percentage of the larvae.

In field tests sodium fluosilicate-lime dust, and pyrethrum soap emulsion with Bordeaux mixture were superior to arsenicals and nicotine in reducing the percentage of wormy fruit.

During the past several years certain promising insecticides have been developed by entomological workers in the control of the Japanese beetle, the Mexican bean beetle, et al. These have been of several types: (1) emulsions of toxic organic materials, e. g., pyrethrum and orthotoluidine which kill by contract; (2) improved forms of arsenical stomach poisons, e. g., coated (oleate) and colloidal arsenates of lead; and (3) fluorine compounds which may act both by contact and as stomach poisons, e. g. sodium fluosilicate and sodium fluoride. Since many of these have proven successful in controlling the insects mentioned it seemed advisable to test their toxicity on two species which are particularly injurious in northwestern Pennsylvania, i. e., the grape leafhopper (*Typhlocyba comes* Say.), and the oriental fruit moth (*Laspeyresia molesta* Busck.). Workers in the past have shown that the grape leafhopper is susceptible to several contact insecticides in the nymph stages and that its eggs are killed by nicotine sulfate. The oriental fruit moth has been shown to be susceptible to nicotine in the egg stage, but the larvae are not readily killed by the ordinary forms of arsenicals. In view of these facts the various emulsions were tested in comparison with nicotine sulfate on nymphs and eggs of the grape leaf-hopper, and the more promising were then tried in control of the oriental fruit moth, The fluorine compounds, of which only sodium fluosilicate was tested. were tried on both insects and the arsenicals were used solely in the oriental fruit moth experiments.

Grape Leaf-Hopper Experiments

The grape leaf-hopper experiments consisted of several phases: (1) laboratory tests to ascertain the relative toxicity of the various compounds on the leaf-hopper nymphs; (2) field-cage tests where the effect of the materials was observed with reference to the eggs and nymphal instars; and (3) field spraying of infested vines to ascertain the control obtainable when the materials were applied on a commercial scale. All

of the compounds tested were used alone and in combination with Bordeaux mixture 8–8–100 which is the standard fungicide employed in grape spray programs. Parallel tests using nicotine sulfate (40%), Bordeaux mixture, and unsprayed material were included for comparison.

Table No. 1 records the results obtained from field sprays of materials which had already proven toxic in laboratory tests. From the counts

TABLE 1. EFFECT OF SPRAY MATERIALS ON NYMPHS OF GRAPE LEAFHOPPER IN FIELD

Material per 100 gal.	Average nymphs per leaf	Total nymphs counted	Number killed	Per cent killed	Remarks
Cocotine 5½ lb.	16	80	71	88.7	Foliage severely burned.
Same in Bordo mixture 8–8–100	18.6	93	76	81.7	Foliage slightly burned; Mixture separates on standing
Derrisol 1 pint	27.4	137	137	100	
Same in Bordo mixture 8–8–100	23	115	113	98	
Pyrethrum soap emulsion 6½ gal.	25.6	128	128	100	
Same in Bordo mixture 8–8–100	18.8	94	94	100	
Black Leaf 40 1 pint	13.8	69	68	98	
Same in Bordo mixture 8–8–100	14.8	74	74	100	
Bordo mixture 8–8–100	13.6	68	7	10.2	
Unsprayed check	17.6	87	5	5.7	

made 24 hours after spraying it will be seen that emulsions of derris ("Derrisol"), and pyrethrum killed the nymphs equally as well as nicotine sulfate, all three materials giving practically perfect control. Moreover they showed no decrease in toxicity when combined with Bordeaux mixture and did not injure the foliage. The emulsion of coconut fatty acids ("Cocotine"), was less toxic, did not mix with Bordeaux, and burned grape foliage. A few nymphs were killed by Bordeaux mixture. The cause of this will be discussed later.

Table No. 2 shows the effect of these same compounds on the nymphal development, particularly the hatching of first instar nymphs. Cages were placed over the foliage immediately after spraying to exclude migrating nymphs and adults, and adults which had survived the spray were removed. Counts made for a period of five days showed that nymphs continued to hatch from unsprayed foliage and from that sprayed with Bordeaux mixture. No first instar nymphs hatched from

TABLE 2. LEAFHOPPER POPULATION ON CAGED FOLIAGE FIVE DAYS AFTER SPRAYING

Material per 100 gal.	Average nymphs per leaf before spray	Average nymphs per leaf after spray	Approximate control %	Average nymphs per leaf by instars after spraying 1	2	3	4	5
Cocotine 5½ lb.	16	4	75	1.7	.8	.8	.4	.3
Same in Bordo mixture 8–8–100	18.6	8.5	54+	1	1.8	1.5	1	3.1
Derrisol 1 pint	27.4	.9	98+	.8	.1	0	0	0
Same in Bordo mixture 8–8–100	23	.6	96+	.23	.07	.07	.3	0
Pyrethrum soap emulsion 6½ gal.	25.6	0	100	0	0	0	0	0
Same in Bordo mixture 8–8–100	18.8	0	100	0	0	0	0	0
Black leaf 40 1 pint	13.8	1.1	90+	0	0	.10	.50	.50
Same in Bordo mixture 8–8–100	14.8	1.3	91+	0	.28	.14	.42	.42
Bordo mixture 8–8–100	13.6	18.2	—	2.6	1.2	3.3	4.0	7.0
Unsprayed check	17.6	20.2	—	3.7	5.7	4.8	2.8	3.0

that sprayed with nicotine or pyrethrum soap emulsion, but hatching continued with the emulsions of derris and coconut fatty acids. A complete disappearance of all instars for the five day period resulted on foliage sprayed with pyrethrum soap emulsion, while with the other materials some nymphs survived, particularly those in the 4th and 5th instars.

In addition to the compounds just discussed, certain other materials were tested in the laboratory and these results are shown in Table No. 3. Sodium fluosilicate in water 1–10 and combined with hydrated lime or Bordeaux mixture killed the nymphs very effectively but burned foliage unless an equal quantity of lime was used with it. Ortho-toluidine emulsion was also quite toxic, but it too burned foliage and did not mix well with Bordeaux. As previously noted, Bordeaux mixture 8–8–100 killed small numbers of the nymphs and various strengths of this material were included in this series and compared with other copper fungicides. These tests showed that Bordeaux mixtures are toxic to small numbers of nymphs in direct proportion to their strength, a 12–12–100 mixture killing about three times as many nymphs as the 8–8–100 mixture. This killing seemed due to the gelatinous consistency of the mixtures and to the caustic action of the lime. Part of the nymphs killed were found glued fast to the leaf surface by the spray film and the remainder developed brown shrunken areas on the body and died 24–48

TABLE 3. EFFECT OF SPRAY MATERIALS ON NYMPHS OF THE GRAPE LEAFHOPPER IN LABORATORY

Material per 100 gal.	Average nymphs per leaf	Total nymphs counted	Number killed	Per cent killed	Remarks
Orthotoluidine emulsion 20 lb.	20.3	61	61	100	
Same with Bordo mixture 8–8–100	21	63	57	90.4	Mixture turns lead colored, materials separate and foliage burning results
Sodium fluosilicate 10 lb., hydrated lime 10 lb.	20	60	60	100	Foliage moderately burned.
Same with Bordo mixture 8–8–100	21.6	65	65	100	Foliage very slightly burned, killing of entire number of nymphs required 48 hours, i. e., 96.9% died in first 24 hours
Hydrated lime 10 lb.	20.8	104	6	5.7	
Bordo mixture 8–4–100	33.4	167	12	7.2	Foliage very slightly burned
Bordo mixture 8–8–100	27.3	219	23	10.5	
Bordo mixture 8–12–100	31.8	159	31	19.5	
Bordo mixture 12–12–100	31.3	94	30	31.3	
Ammoniacal copper carbonate 6–12–100	20.3	61	0	0	
Copper hydroxide 6 lb.	26	104	5	4.7	
Check	14	56	1	1.8	Sprayed with plain water

hours later. The same behavior was noted to a less extent in nymphs sprayed with hydrated lime and with copper hydroxide, but not with ammoniacal copper carbonate. In the check material a few nymphs died while attempting to moult. Bordeaux and lime sprays tended to increase this phenomenon.

ORIENTAL FRUIT MOTH EXPERIMENTS

During the course of the grape leaf-hopper work investigations were in progress with the second generation of the oriental fruit moth and twigs containing larvae were treated with the emulsions which proved successful in leaf-hopper control. None of these killed the larvae within the twigs but it was observed that pyrethrum soap emulsion often stunned them to such an extent that they were unable to infest new twigs.

This material was included in the routine fruit moth work, which consisted of a laboratory investigation of a number of spray materials, and

TABLE 4. EFFECT OF CAGING ORIENTAL FRUIT MOTH LARVAE WITH SPRAYED OR DUSTED FRUIT. INDIVIDUAL PEACHES USED

Liquids: Material per 100 gal.	Total larvae used	Total killed	% killed	Effect in relation to size of larvae: 2–5 mm. No. entered	2–5 mm. No. dead	6–9 mm. No. entered	6–9 mm. No. dead	10–15 mm. No. entered	10–15 mm. No. dead	No. in cocoon
Pyrethrum soap emulsion 10 gal.	15	7	46.6	1	4	3	2	1	1	3
Same in Bordo mixture 8–12–100	12	9	66.6	0	3	0	3	1[1] 2[4]	3	0
Pyrethrum soap, Bordo 8–12–100						1[3]				5
Sodium fluosilicate 10 lb.	16	13	81.2	0	1	1[3]	3	0	5	4[2]
Pyrethrum soap, Hydr. lime 20 lb. Sodium fluosilicate 10 lb.	14	10	71.5	0	2	2		2	2	0
Hydr. lime 20 lb. Sodium fluosilicate 10 lb.	11	10	90.9	0	4	1	2	0	4	0
Bordo mixture 8–12–100, Sodium fluosilicate 10 lb.	16	8	50	0	4	0 4[4]	2	0 2[4]	2	2
Black leaf 40 1 pt. Hydr. lime 12 lb.	14	4	28.5	2	4	4	0	2	0	2
Kerosene Emulsion 7%	10	2	20	2	2	0 2[4]	0	0 2[4]	0	2
Lead arsenate 2 lb. Hydr. lime 4 lb.	12	3	25	3	3	3	0	0	0	3
Unsprayed check	12	0	0	0	0	6	0	3	0	3
Dusts: Pyrethrum 5 parts, sodium fluosilicate 1 part Hydr. lime 5 parts	17	12	70.6	0	4	4	3	0	3	2[3]
Sodium fluosilicate 1 part, hydr. lime 10 parts	10	6	60	0	2	4	2	0	2	0
Nicotine-lime dust 4%	6	2	33.3	0	2	2	0	2	0	0

[1]Larva entered thru injury.
[2]Larvae abandoned cocoons and died.
[3]Larva abandoned fruit and died.
[4]Larvae missing.

field tests of those which were found promising and safe for commercial use.

In the laboratory third generation larvae of graded size were caged with peaches which had been sprayed or dusted with the various materials. When liquids were used the spray was allowed to dry before the larvae were introduced. Table No. 4 shows the results of these tests. It will be seen that the greatest numbers of larvae were killed by liquid sprays of pyrethrum soap emulsion and sodium fluosilicate in combination with hydrated lime or Bordeaux mixture or with dusts containing similar ingredients.

The effectiveness of the dusts was slightly less than that of the liquids. The greatest protection afforded the fruit, as ascertained by records of larval entrance, was from a liquid spray of pyrethrum soap emulsion, sodium fluosilicate, and Bordeaux mixture. Larvae placed on fruit sprayed with the pyrethrum soap emulsion combinations were characterized by restlessness, unsuccessful attempts to enter the fruit or spin cocoons, gradual paralysis and death. Sodium fluosilicate was more directly toxic and larvae usually died in 48 hours even though they entered the fruit. Larvae 6–9 mm. long were most resistant to all of the materials tested.

As noted by Peterson,[1] dusts containing hydrated lime killed many of the smaller larvae and it is possible that the benefit received from all of the combinations containing lime was in part due to it.

In the field investigations small plots of Elberta peach trees were sprayed and dusted at the time the adults of the third generation were flying in greatest abundance. The second generation larvae had confined their feeding to the twigs and to the fruit of early varieties and the Elberta fruit was practically uninfested.

Sheets were placed under the trees, and the dropped peaches were collected and examined. At harvest the picked fruit was split and the infestation determined. Table No. 5 lists the materials tested and the infestation of the picked and dropped fruit. The only decided reduction in the percentage of wormy fruit occurred in the plot sprayed with pyrethrum soap emulsion and Bordeaux mixture, and the plot dusted with sodium fluosilicate and hydrated lime, the pyrethrum-Bordeaux plot showing 50% infestation, the sodium fluosilicate plot 47%, and the unsprayed check 75% infestation. Sodium fluosilicate in liquid

[1]Peterson, A., Some Studies on the Effect of Arsenical and Other Insecticides on the Larvae of the Oriental Peach Moth; JOURNAL OF ECONOMIC ENTOMOLOGY 13, 4: 391.

form was omitted because of the danger of burning the peach foliage. Coated and colloidal arsenates of lead did not prevent severe infestation of the fruit. A liquid spray of nicotine sulfate and lime reduced infestation to a small extent.

TABLE 5. SUMMARY OF FIELD TESTS FOR ORIENTAL FRUIT MOTH CONTROL

Liquids: Material per 100 gal.	Number fruit examined	Number fruit infested*	% fruit infested	% dropped fruit infested	% picked fruit infested
Pyrethrum soap emulsion 10 gal.					
Bordo mixture 8–12–100	637	321	50.3	94.7	49
Kerosene emulsion 7%	435	306	70.3	82	69.5
Black leaf 40 1 pint, hydr. lime 10 lb.	361	232	64.2	71.4	63.3
Lead arsenate 2 lb., hydr. lime 4 lb.	230	193	83.9	86.6	84
Colloidal lead arsenate 1½ lb.	228	158	69.3	85.7	67.8
Coated (oleate) lead arsenate 10 lb.	136	104	76.4	83.3	76.1
Unsprayed check	143	107	74.8	100	71.3
Dusts: Sodium fluosilicate 1 part					
Hydr. lime 10 parts	655	306	46.7	68.1	45.9
Nicotine lime dust 4%	175	142	81	94	76

*All fruit split to determine infestation.

MR. H. L. DOZIER: What is the pyrethrum soap that you used?

MR. J. R. EYER: The "Jap beetle Whiz spray." We didn't have enough of the soap prepared by the Japanese Beetle Laboratory to use it in all our experiments. What we used here was the regulation "Jap beetle Whiz spray" manufactured by R. M. Hollingshead Company, Camden, N. J.

MR. H. L. DOZIER: What strength?

Mr. J. R. EYER: One gallon of the spray to fifteen gallons of water.

MR. H. L. DOZIER: I used this same preparation, at the rate of one to one hundred and one to fifty against the apple leafhopper and the grape leafhopper, and we got excellent results at a temperature of about 100, I think it was. When it dropped to 64 it was an absolute failure.

MR. J. R. EYER: Our temperature at the time this spraying was done was between 70 and 75. I know that on the leafhopper you can use it at a lower strength than we did in the field; we kept those high strengths on the peach because we knew that it would take the highest strength possible on the peach to have any effect on the moth, and even then it didn't have much. The fact that none of the leafhopper eggs hatched from the foliage after it was applied seemed to indicate that it has the same type of ovicidal value as Ross noted for nicotine.

MR. T. H. PARKS: We had one grower in Ohio last year who was made violently ill and required the services of a physician. He had been spraying with nicotine and bordeaux mixture for years and had never had such ill effects before to my knowledge.

MR. J. R. EYER: I didn't note that trouble with the pyrethrum at all. I always get sick with nicotine, because I don't smoke, I guess.

MR. F. C. NELSON: I worked with pyrethrum sprays all summer in closed buildings where the air was so thick with some of the commercial fly sprays that you couldn't see across the room, and never noticed any ill effect. I worked with cattle, hogs, and practically all farm animals. I don't think there is a possibility that the pyrethrum spray would make anybody sick.

MR. ROGER BALDWIN: If you will take a cathartic at the end of the day of spraying, you will not have any injurious effect.

PRESIDENT ARTHUR GIBSON: We will now listen to a paper by C. C. Hamilton.

THE RELATION OF LEAF AND TWIG GROWTH OF TWO VARIETIES OF APPLES TO THE QUANTITY AND ADHERENCE OF LEAD ARSENATE THROUGHOUT THE SPRAYING SEASON

By C. C. HAMILTON, *New Brunswick, N. J.*

ABSTRACT

Weekly measurements of twig growth in inches and leaf growth in area were made throughout the growing season, on tagged twigs on several apple trees. Foliage was collected at each of the dates of measurements and analyses made for lead arsenate. These results are correlated with the increase in leaf area and twig growth. At the end of the spraying season the leaves on the tagged twigs were collected, separated into groups according to the dates when they first appeared and analyses made for lead arsenate. These results are correlated with the growth of leaf area.

(Withdrawn for publication elsewhere)

PRESIDENT ARTHUR GIBSON: V. I. Safro will now present a paper.

ADAPTING FUMIGATION PROCEDURES TO INDUSTRIAL NEEDS

By V. I. SAFRO, *Arcade Station, Los Angeles, Calif.*

ABSTRACT

Discussing some basic principles of industrial fumigation, including the dosage range, air circulation during fumigation, penetration, retention and correcting some former ideas on absorption of HCN by foodstuffs.

In the course of many experimental and commercial fumigations conducted by the writer for the control of insect pests as industrial

problems, a number of procedures usual in agricultural work were found unsuitable for industrial use. Some former basic concepts required radical modification and occasionally the establishment of entirely new principles.

This paper discusses briefly several of these new and modified principles. The writer's fumigations have been almost entirely with commercially pure calcium cyanide, but the principles involved apply generally to all fumigations.

Food, clothing and shelter continue to be the objects of insect attack after the materials have left the field as growing agricultural crops and entered the industrial world as basic commodities. Modern concepts of sanitation call for measures of insect control that, because of the closer contact of the problems with our every day lives, are far more pressing than the original problem affecting the growing crop. The agricultural crop called for protection from destruction and deterioration. Industry calls for protection not only from direct injury to its products but also from those many conditions that may affect the physical welfare or even the mental attitudes of its workers, its customers or the general public.

Agriculturally—as the word is generally used—the presence of predaceous insects is very much desired. In a package of cereal, however, a predaceous insect is as objectionable as the pests it preys upon. Parasitized insects are welcome sights in agricultural infestations, but there is nothing to inspire welcome in the sight of parasitized larvae in a package of dried fruit.

Considerable financing is conducted at present based upon stocks of agricultural products in bonded warehouses. Tobacco, grain, wool, peanuts, beans, dried fruits, may lose much or all their value if not properly protected from insect pests. Railroad, steamship and insurance companies are faced with claims for insect damage to freight and cargo, on the complaint that the infestations took place in transit.

The Dosage Range

In the literature recommendations generally give a fixed dosage and exposure without regard to practicability. The simplest example of this type of problem—household fumigation—may be taken. Published recommendations generally call for an overnight exposure—or even longer. To most families it is a hardship to remain away from home overnight. It is expensive. And yet, too often, the literature offers no relief—notwithstanding that household fumigation for insect pests can now usually be conducted effectively in a few hours.

Dosages can generally be worked out for an entire range of exposures from minimum quantity of fumigant on the one extreme to minimum length of exposure on the other. The interest affected can then choose the dosage and exposure that more nearly meets its requirements. In ship and car fumigation the time element is usually of major importance and the shortest exposure would be preferred. In warehouse fumigation frequently the lowest dosage would be preferred—with overnight or week-end exposures.

Air Circulation and Penetration

A dosage range worked out for an insect not buried in any medium gives no indication as to dosage ranges necessary for the control of the same pest when it occurs in commercial packing. A dosage range for commercially packed material must be worked out for each type of packing. Fine flours will be more difficult of penetration than coarse cereal products. Pressed products are more difficult of penetration than those loosely packed.

Penetration must be obtained at minimum interference with the industrial procedure concerned. Installation of expensive vacuum equipment is not often permissible or practical. The fumigation procedure must be worked out in a manner that will not call for more than minor changes in the structure of the building or any of its rooms.

In adapting fumigation procedures to industrial needs the writer has found that penetration is considerably increased by circulating the air in the room or building during the fumigation. This principle is now being used by the writer in all fumigations that include a penetration problem.

Air circulation during the fumigation increases efficiency in several ways. More efficient diffusion of the gas takes place and the air movement tends to displace dead air in the packing with the poisoned air circulating in the room. Where calcium cyanide is used as the fumigant, air circulation insures the more complete contact of atmospheric moisture with the calcium cyanide particles, a more complete evolution of HCN and a higher concentration in a shorter period of time than if no air circulation is provided.

Retention of Gas in Packed Material

The retention of gas in the fumigated package is undoubtedly a factor in the insecticidal efficiency of fumigations. It is known definitely that the gas does not immediately leave the package at the end of the commercial fumigation. Its rate of departure depends upon many

factors, such as density and humidity of the product itself, penetrability of the packing material, ventilation, etc., though in some instances the retention may be so poor as to be negligible as a commercial factor. To investigators this principle is significant in that the factor of time elapsed between the end of the fumigation proper and the opening of the package may affect the results of experiments. In working out a dosage range on packed material, the mortality examinations could well be made after an interval of time sufficient to permit of the full effect of any retained gas. This factor, if present at all, would certainly be active under commercial conditions, for, after all, in actual practice very few, indeed, are the cases where the product is unpacked immediately after the fumigation.

Absorption of HCN by Foodstuffs

Unfortunately, too much information on the absorption of HCN by foodstuffs has been misleading. To record in scientific publications the results of routine analyses of foodstuffs for the presence of HCN is, of course, permissible as contributions to our technical knowledge of the subject. To issue such information broadcast to the non-technical reader is unfortunately likely to add to the misinformation he already has on the subject—even when qualifying statements are included indicating the lack of real significance of the analyses made.

An analysis showing presence of HCN in foodstuffs does not definitely indicate (except under extreme conditions) whether the product is likely to be injurious to human health. It is a well-known practice of fumigators, after the fumigation of restaurants, ships and similar places in which ready food is stored, to partake of the fumigated food immedately after clearing the gas. The writer has, without any ill effects whatever, partaken heartily of fumigated sliced bread, cut pie, sticky figs, coffee and other foods shortly after the completion of fumigations. Undoubtedly, analyses of this food would have shown the presence of HCN, and there is no question whatever that much food containing traces of HCN is eaten without immediate or cumulative effects of any kind.

A statement of the percentage of HCN in food would hardly indicate its safety without the additional information as to the probable amount of such food a normal person would have to eat at the time of the analysis in order to show toxic symptoms. Analyses of foodstuffs for the presence of HCN should be made in accordance with quite evident—but generally overlooked—factors, especially in the fumigation of commercial establishments in which food products are manufactured or stored. Not

only should the normal interval of time between the fumigation and the time the article reaches the consumer elapse before the analysis is made, but the handling of the product commercially should be duplicated in order to arrive at analyses that would more nearly approach actual conditions in commercial practice; such as transportation in freight cars under more or less ventilated conditions, handling out of the cars into warehouses, shipment out of warehouses by trucks to stores and handling of indivudual packages from stores to the consumer.

In addition to time elapsed and handling in transportation, foodstuffs should be subject to the usual kitchen and table preparations before analysis; such as mixing with other ingredients, sifting, dissolving, cooking, slicing, etc. Even in the simplest case, such as cheese, a logical analysis cannot be made without first slicing the cheese—assuming, of course, it is that type of cheese. To analyze uncooked flour for traces of cyanide would be just as misleading—naturally, the flour should be properly prepared and baked. Then it is in order to make an analysis of the edible product. The factors of increased aeration, dilution and possible decomposition enter so prominently into food preparation that it is quite inconceivable to permit of analyses with any practical significance without taking them into consideration.

Some Evidences of Industrial Interest

A number of industrial practices at present under way indicate the importance with which fumigation is being regarded industrially. The widespread adoption of flour mill fumigation is well known. The fumigatorium is finding an established place in a number of industries; such as tobacco, package cereals, beans, dried fruits, furs and warehousing. It often does double duty—it serves its purpose for outgoing shipments, to protect the consignee, and also for incoming material for the protection of the foods and premises concerned.

One large dried fruit organization guarantees its products to arrive insect-free in the hands of the consumer throughout the world. Cereal mills are beginning to advertise insect-control treatment of their products. Cigar factories are including in their service fumigation of all shipments. It is a usual practice in the two latter industries to accept the return from purchasers of infested material—even in cases where it is quite evident the infestation occurred in transit or on the premises of the purchaser himself.

Warehouses are featuring fumigation as part of their service. One of our largest railroads has recently appointed a fumigation manager, who is organizing a department to take over the railroad's fumigation

activities. One of the largest chains of flour mills, warehouses and elevators in the country recently assigned a member of its organization to an investigation of fumigation procedures with the intent of establishing a complete program of insect control from the line elevator to the consumer of the manufactured cereal product.

The fumigation of empty cars, ships and other channels of trade is being advocated and slowly adopted. An evidence of the interest in this matter is a recent meeting of representatives of the export flour milling industry, railroads, steamships and marine insurance, to consider ways and means of reducing insect infestation of mill products in transit.

All of these developments indicate the need for greater extension of fumigation procedures to meet industrial demands. They indicate the need of proper coordination of the investigations to the industries concerned, with the findings, written after some practical contact with the industry and in the language familiar to it, finally recorded in the proper trade publications.

MR. PEREZ SIMMONS: I should like to ask Mr. Safro if it is dangerous to fumigate any raw food products. Ordinarily the recommendations have been to remove milk from dairies.

MR. V. I. SAFRO: Many food products are regularly fumigated. The Bureau of Animal Industry has approved fumigation of meats with HCN. That was a number of years ago. Milk, coffee and a few such things are occasionally removed before fumigation, but in actual practice, such as ship fumigation, there is no food removed from the kitchen, or whatever they call it on board a ship. The same holds true in restaurants and hotels. Sometimes cut onions and such things are removed, but the usual experience is to disturb nothing at all until after the fumigation, and then the fumigating crew usually helps itself to what there is in the kitchen, with no ill effects.

I have gone through the literature, not only the technical but the commercial and the popular, and have had correspondence with a number of practical as well as technical fumigators and also correspondence with investigators. I don't know of a single case of human poisoning from food that had previously been fumigated.

MR. PEREZ SIMMONS: Nearly all the trouble has been due to carelessness on the part of the fumigators or due to accidental injuries to people who have been in the fumigated areas.

MR. V. I. SAFRO: Yes, the troubles that have been recorded are generally inhalations of the gas rather than ingestion of the food that

has been fumigated. After all, a chemical anaylsis will indicate such minute quantities of HCN in the food product as to mean nothing practically.

MR. WILLIAM MOORE: The United States Health Service have carried out a few experiments with mice and fumigated bread. They killed a few mice when the bread contained so much gas that the miee were killed before they ate the bread, but as long as the mice were able to live through the gas and eat the bread, they survived. (Laughter.)

PRESIDENT ARTHUR GIBSON: The next paper is by B. F. Driggers.

CALCIUM CYANIDE AS A CONTROL FOR THE CRANBERRY ROOT WORM ON CULTIVATED BLUEBERRIES[1]

By BYRLEY F. DRIGGERS, *Associate Cranberry Specialist, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey*

ABSTRACT

The cranberry root worm (*Rhabdopterus picipes* Oliv.), a common insect on cranberry bogs, has become recently an important enemy of the cultivated blueberry. An outline of the life history and habits of the larvae and adults is given. Experiments with sodium fluosilicate used against the adult failed to give a satisfactory kill. Experiments with both the dust and granular calcium cyanide used against the adults indicate that the insect can be controlled with the granular calcium cyanide.

INTRODUCTION

The cranberry root worm[2] has been known for a number of years as a feeder on the roots and foliage of cranberries and other bog plants, including the swamp blueberry. Damage from this insect in the past has usually occurred on the so-called savannah bogs the soil of which is made up chiefly of sand. During recent years a number of old run-down or abandoned savannah bogs have been plowed up and made into blueberry plantings. The clean cultivation of the plantings caused the beetles to concentrate on the blueberry plants in such numbers that it became necessary to work out some measure of control. This paper is a summary of the main points brought out in the investigation of the subject during the past year.

HABITS OF THE LARVAE AND ADULTS

The principal damage to the blueberry plant is caused by the larvae feeding on the small, fibrous roots. The larvae feed throughout the summer and pass the winter in the soil. Pupation takes place the

[1]Paper No. 330 of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Entomology.

[2]*Rhabdopterus picipes* Oliv. Fam. *Chrysomelidae.*

following spring or early summer, according to Scammell (4), who worked out the life history of this insect. The adults begin emerging about the middle of June and are to be found in maximum numbers during the latter part of June and the first of July. The beetles feed to some extent on the foliage at night and on dark cloudy days. On bright, sunny days they are to be found under loose soil, leaves and other places of concealment at or near the base of the plant. Field collections showed that the majority of the beetles find shelter within eighteen or twenty inches of the plants. With the above mentioned habits of the beetle in mind, we decided to test two of the more recent insecticides; namely, sodium fluosilicate and calcium cyanide.

Results Obtained with Sodium Fluosilicate

Preliminary laboratory and field experiments with the so-called "light" and "extra light" sodium fluosilicate gave little or no control. The detailed experimental procedure is omitted here. However, certain observations on the actions of the beetles when in contact with the sodium fluosilicate may be of interest. On coming in contact with the dust the beetles became extremely active. They would attempt to fly and, falling back, would crawl aimlessly over the bottom or up the sides of the cage. The beetles would stop frequently and rub their legs together in an effort to free themselves of the dust. At no time were the beetles observed cleaning their feet with their mouth parts. In this last point the actions of the cranberry root worm differ from those of blister beetles, the Mexican bean beetle and the cotton boll weevil as reported by Ingram (1), Marcovitch (2) and Osburn (3) respectively. This difference in the actions of the cranberry root worm and the actions of the other insects mentioned explains possibly the difference in control.

Preliminary Tests with Calcium Cyanide

The calcium cyanide used in the following experiments was the Grade "A" Cyanogas dust and the granular calcium cyanide furnished by the American Cyanamid Company of New York City. The experimental procedure was as follows: Twelve blueberry nursery plants about a foot in height were covered with suitable wire cages. Ten beetles were introduced into each of the twelve cages. As soon as the beetles had concealed themselves around the base of the plants, one-tenth ounce of the calcium cyanide dust was sprinkled around each of five plants. Five of the remaining seven plants were treated with an equal quantity of the granular material. The soil around the ten treated plants was stirred lightly in order to mix the calcium cyanide with the

moist soil and to bring the beetles in contact with the gas. The number of apparently dead beetles at the end of one, three and twenty hours is set forth in Table 1.

TABLE 1. TEST OF CALCIUM CYANIDE DUST AND GRANULES USED AGAINST THE CRANBERRY ROOT WORM. TEN BEETLES TO EACH CAGE

Number of cage	Material used	No. apparently dead beetles 1 hr.	3 hrs.	20 hrs.	Remarks
1	Dust	10	9	8	
2	Dust	9	9	7	
3	Dust	10	9	8	
4	Dust	10	10	8	
5	Dust	9	9	9	No injury to plants after treatments
6	Granular	10	10	10	
7	Granular	10	10	10	
8	Granular	10	10	10	
9	Granular	10	10	10	
10	Granular	10	10	10	
11	Check	0	0	0	
12	Check	0	0	0	

An examination of the data in Table 1 shows that, of the two types of material, the granular calcium cyanide was the more effective. A complete kill was obtained with this material. In the case of the dust all of the beetles except two appeared to be dead at the end of one hour. At the end of three hours two of the apparently dead beetles in the dust cage had recovered and at the end of twenty hours six more had recovered. It appeared that the evolution of the gas from the fine dust particles was so rapid that the beetles were not exposed to a lethal concentration of the gas for a sufficient length of time to obtain a complete kill.

FIELD TESTS WITH GRANULAR CALCIUM CYANIDE

The cage experiments mentioned above were carried out June 29th–30th. On July 10th, the soil around fifteen of the more heavily infested field plants was treated with one-half ounce granular calcium cyanide to each plant. The cyanide was sprinkled around the plants in a circular area extending about a foot from the plant. Immediately after the material was applied the soil was raked lightly toward the plant. This procedure mixed the calcium cyanide with the moist soil and uncovered many of the concealed beetles. The treatments were made about noon on a clear day with the temperature of the air at 32°C.

Three hours after the treatments were made the loose soil from around five of the treated plants was scooped up and screened to recover any beetles present. Over 95% of the beetles were found dead. The detailed results are set forth in Table 2.

TABLE 2. RESULTS FROM FIELD TEST WITH GRANULAR CALCIUM CYANIDE USED AGAINST THE ADULT OF THE CRANBERRY ROOT WORM

No. of plant	Amt. cyanide used	No. dead beetles	No. live beetles	Remarks
1	.5 oz.	11	1	
2	.5 oz.	23	0	No injury to
3	.5 oz.	21	3	plants after
4	.5 oz.	21	0	treatment.
5	.5 oz.	9	0	

No injury was noticed on any of the plants after the treatment. Additional tests were run to determine what dosages would cause injury to the plants. Five plants were treated with dust and five with the granular material in amounts ranging from one-half to two and one-half ounces. Foliage in contact with or near the soil was burned slightly with dosages of one and one-half ounces or above. As the damaged foliage was chiefly sucker growth, which is removed by the winter pruning, the real damage to the plants was practically nothing even in dosages as high as two and one-half ounces. The average moisture content of the soil around the treated plants was 15.6% and the average soil temperature was 28.4°C.

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PRESIDENT ARTHUR GIBSON: We will now listen to a paper by C. O. Eddy.

CYANOGAS CALCIUM CYANIDE FOR HOUSEFLY FUMIGATION IN CERTAIN TYPES OF BUILDING

By C. O. EDDY, *S. C. Experiment Station*

ABSTRACT

Hydrocyanic acid gas derived from Cyanogas calcium cyanide has proven an effective and economical fumigant for houseflies at Clemson College, S. C., during the past season, especially in large rooms such as dairy barns, stores, shops, laboratories and under certain conditions in homes. The calcium cyanide was usually applied as a dust cloud thrown vigorously and horizontally from a cupped stiff paper held in the hand. In homes, feed rooms for animals and in other rooms where a dust cloud could not be used or where it was not advisable to have the dust fall to

the floor, the calcium cyanide was applied as a thin film on papers placed in several parts of the room. The normal dosage used in commercial control ranged around ½ ounce per 1000 cubic feet, being slightly less in large rooms with very little leakage and more as the leakage increased, the increase being greatest in the smaller rooms. Night fumigations were more convenient and were usually more effective. The evolution of the gas from the dust clouds was slow enough to allow sufficient time for a thorough application, and the concentration of hydrocyanic acid gas necessary for a lethal dosage for flies is low enough to allow a considerable margin of safety for the operator.

In spite of the fact that it is better to control the maggots of the housefly it is often desirable and sometimes very necessary or urgent to control the adults. The latter condition prevailed at Clemson College, S. C., due to the great abundance of houseflies that existed throughout the last season. Experiments were therefore conducted to determine an economical method of control that not only could be easily applied but would be adaptable to large scale control. Traps and poison solutions had but very little value. Black Flag, commercial pyrethrum and the more recently developed oil sprays had their usefulness under certain conditions but their cost was high.

The experiments reported in this paper represent results for only one season but they were so highly satisfactory it is thought that they will be interesting and useful to other Entomologists. These results were obtained during a hot and very dry summer. The former, at least, may be considered a favorable condition for Cyanogas calcium cyanide as an insecticide.

Object

The object of the experiments reported in this paper was to determine the value of hydrocyanic acid gas derived from Cyanogas calcium cyanide as a housefly fumigant.

Method of Application

Nearly all of the calcium cyanide used in the housefly control tests reported was applied as a dust cloud without the aid of a dust gun. Small amounts of calcium cyanide were successively poured on a strong paper or cardboard that was slightly cupped as it was held in the hand. Each portion of dust was then thrown vigorously and horizontally from the operator so that a dust cloud was formed. The dust was distributed as evenly and uniformly throughout the rooms fumigated as conditions would permit, care being taken that the operator would not have to walk through the dust cloud. The operator has, however, walked through these dust clouds but has always held his breath when doing so. The gas from these clouds of dust spread slowly enough so that there

was always sufficient time to make a thorough application of the poison. The evolution of the gas from the cloud of dust also takes some time, which in addition to the diffusion of the gas in the air, adds to the safety of applying the dust. The question of the margin of safety relative to the concentration of hydrocyanic acid gas necessary for a lethal dosage to flies is included in the section "DISCUSSION."

In certain shops, feed rooms for animals, and other rooms where a dust cloud could not be used or where it was not advisable to have the dust fall to the floor, the calcium cyanide was applied as a thin film on papers placed on the floor so that the hydrocyanic acid gas would uniformly diffuse throughout the room.

PRELIMINARY TESTS

A few tests were conducted in a large laboratory in the Agricultural Building where a considerable number of houseflies accumulated each day. This room contained 18,772 cubic feet. It had plastered brick walls and well-fitted windows and doors so that the amount of leakage was small. The tests were usually started at night after the flies had collected in the upper portion of the room and discontinued the next morning. Rooms were well ventilated when opened but were occupied at once.

A dosage of eight ounces of calcium cyanide per 1000 cubic feet was used in the first test. This gave 100% control. A dosage of ⅛ ounce per 1000 cubic feet was then used and many flies survived but enough were killed to indicate that the first dosage was far too high and that a small dosage would probably be sufficient. Three-fourths of an ounce of calcium cyanide was then used and 100% control was again secured. Other tests gave results as follows: .30 ounce gave 100% control, .27 ounce gave 98% control, .24 ounce gave 99% control, and .14 gave from 60% to 70% control. These results indicated that a dosage of slightly less than ½ ounce calcium cyanide per 1000 cubic feet could be used for night fumigation in relatively large rooms having very little leakage. In practice ½ ounce per 1000 cubic feet was used in this room to obtain control.

It was found in certain experiments started before the flies were all in the upper portion of the room, that those concealed in waste paper baskets or other low places often did not receive a lethal dosage. These slowly recovered and were active for a time at least. This indicates that places concealing or protecting flies should have a small portion of the dust scattered in or about them. This will either kill the flies

in situ or drive them out to be killed as they fly in the greater concentration of gas in the higher parts of the room.

The expended residue on the concrete floor was swept up the next morning. This was done by the negro janitor who experienced no discomfort.

Cage Tests

In order to study the effect of the distribution of gas concentrations in different parts of a room being fumigated and the consequent effect on houseflies, fumigation tests were conducted in several laboratories where flies were confined in wire cages placed in different situations. Since the previous experiments primarily concerned flies in the upper portion of the room, this test was conducted chiefly to determine the effect on those in the lower spaces—9 feet and below.

The cages were built of 16 mesh screen wire, 18 inches in height, 15 inches in diameter and with a solid top. Between 100 and 200 flies were caught in each cage by swinging it through their swirling masses, in a feed room where they were abundant. Cloth was then tied over the bottom to prevent escape. Three of the cages containing houseflies were usually placed in each room to be fumigated, one being placed on the floor, one on a table or cabinet with a large top and the third on an electric light cord about 9 feet from the floor. Cages were read about two hours after the tests were discontinued.

The cage experiments were conducted with varying dosages and time exposures. With a dosage of one ounce of calcium cyanide per 1000 cubic feet the control approximated 100% with the exposures of one, two, three, and five hours. The variation in control was very little and was not correlated with the duration of exposure.

With a dosage of ¼ ounce, ½ ounce, or ¾ ounce in the same situation, however, the longer exposures were more effective. The five hour exposure was thus more than twice as effective as the one hour exposure. The ½ and ¾ ounce dosages gave commercial control since they gave 92% and 96% control respectively in the long period tests. In short tests they were inadequate for these low cages. For night fumigations when the flies were in the upper portion of the rooms the results might have been better. The ¼ ounce dosage per 1000 cubic feet was not adequate for control even during the long exposures.

When one ounce of calcium cyanide was used per 1000 cubic feet the results in control obtained in cages at different elevations and in different situations were very uniform. With the lower dosages, however, the contrast was more evident. The highest cages when hanging free in

space had the highest per cent of dead flies. Cages on tables with large tops, on cabinets especially in corners, or near windows often gave less control than that secured in cages on the floor. This indicates that when fumigation is done in the daytime, at least, a small portion of the dust should be scattered in places where the gas does not circulate well, especially if flies are present in these places.

One series of tests was conducted in a small dark room which was unusually high in proportion to the floor size. Control in this room was always very poor. It was thought at first that the damp unplastered brick walls might have been a factor. However, a test was being conducted in another dark room of normal proportions where the walls were unplastered and as moist but where the control secured was uniform with that in the other rooms. It seems, therefore, that because of the unusual height of the room in contrast to its width and length, the hydrocyanic acid gas rose quickly to the upper portions of the room so that only a very small amount of it diffused through the air in the lower part and this was not effective against the flies which were in cages on or near the floor. Thus it may be necessary to increase the dosage in rooms that are excessively high in proportion to floor size, especially if the fumigation is done during the day.

All of these tests were conducted in basement laboratories while the rooms above were occupied. The only ceiling leakage was around pipes that went through to the rooms above. This leakage was never noticed. When rooms were opened after a test some gas escaped into the hall which rose to the third story but this never caused any inconvenience or interfered in any way with the work on that floor.

Tests in Stores

A series of tests was conducted in several grocery stores, restaurants, and drug stores including both brick and frame structures. The volume of the rooms fumigated usually ranged from 10,000 to 15,000 cubic feet. In order that the first experiment might be certain to give satisfactory control one ounce of the calcium cyanide per 1000 cubic feet was used. This gave 100% control, as far as could be ascertained. In the later tests the ½ ounce dosage was used. The control secured was always 100% or very near to it. In one very irregular corner room with many windows and doors a very few flies often escaped when this dosage was used.

Flies caught between screen doors and the main door should be driven out before the fumigated rooms are entered.

The owners and managers of these stores were enthusiastic about the economical and satisfactory housefly control so easily obtained. They often asked for additional fumigations.

Hog Feed Room

A feed room for hogs of about 1000 cubic feet capacity was fumigated a number of times for flies that accumulated in immense numbers each day. It was estimated that 400,000 flies were in it during each fumigation. The room was a frame structure with weatherboards on the outside and ceiling on the inside. Two single windows and a door occupied three sides. There was a large amount of leakage, part of which was closed with wet paper and burlap. The calcium cyanide was applied as a thin film on newspapers. The results of these fumigations may be summarized as follows: .54 ounce of calcium cyanide per 1000 cubic feet gave 50% control of the flies, 1.50 ounce and 2.18 ounce dosages gave 99.9% control and the 3.27 ounces gave 100% control. The one ounce dosage gave commercial control, as in any case it was necessary to repeat the control very often due to the fact that great numbers of flies entered during each day. On windy nights the loss of gas on the windward side was very great, so this may have accounted in part for the necessity of so high a dosage.

House Fumigation

A little additional information was derived by using calcium cyanide in the home of the writer. The dust was applied on newspapers in every case. The dosage was higher because the building was a frame structure and the ceiling above loosely fitted.

Fumigation tests were conducted when rooms below and adjacent were occupied. No tarnishing of walls, or household equipment was ever noted.

Dairy Barns

Fumigation tests were usually conducted at the dairy barns at night, *after the stock had been turned out*, beginning about 10 P. M. and being discontinued about 4 A. M. The illustration, Plate 5, shows the inside of one of these barns. It has three large ventilators about two feet in diameter, a large number of windows fitted only moderately tight, one set of large double sliding doors at either end in the middle and a double height door at one end in each corner. A very large amount of leakage occurred around the doors and some around the windows but this did not necessitate the increase in dosage as it did in the small rooms.

The volume of each barn was the same,—64000 cubic feet. The calcium cyanide was dusted uniformly in the three longitudinal alleys and at the ends. In this room much of the dust cloud remained suspended for some time, some of it even rising several feet and spreading so a very thorough mixture of dust and air took place. This resulted in a rapid evolution of the gas that spread to all parts of the room.

A preliminary test using one ounce of calcium cyanide per 1000 cubic feet was first run without the ventilators being closed or the windows being repaired in order to determine whether control in these large rooms would be possible. The test was highly satisfactory, nearly all of the flies being killed, so the ventilators were closed and the broken window panes replaced. The dosage was then decreased to ½ ounce and, again, nearly all of the flies were killed. The flies that escaped were chiefly around the windows but many of the flies even in these situations were killed. Nearly all the flies were on the ceiling at night, however, so those that did not receive lethal dosages were few.

A dosage of three-fourths ounce with the ventilators open did not give as good control as the half ounce dosage with them closed.

When fumigations were conducted during the day some flies escaped through the leakage around the doors at the ends. Some of the flies near the doors recovered since the toxic gas was around them but for a very short time. Flies in mangers were killed not only more slowly than those on the ceiling but some recovered from the paralysis while a few were only partly affected.

The ½ ounce dosage was used to control flies in the barns in a commercial way after the experiments were discontinued.

Prior to these experiments Black Flag was used twice per week, the application being made from a rotary gun. The duster was operated by a man on top of a tower built on a feed truck that was pushed along the feed alley in the center of the room. The Black Flag cost $2.50 to $3.00. The cost of the two pounds of calcium cyanide for the one-half ounce dosage was 50 cents which represents one-fifth or one-sixth that of the Black Flag fumigation for materials alone. These prices are based on large quantity purchases in both cases. In addition the use of the dust gun and services of the extra man were eliminated.

Discussion

In using calcium cyanide the dangerous properties of the gas evolved should be constantly in mind in spite of the fact that the margin of safety in the concentration of the gas used is considerable. In the Journal of Agricultural Research Vol. XI No. 9, 1917, DeOng says that

Interior of dairy barn fumigated for house flies.

the concentration of hydrocyanic acid gas necessary to kill houseflies 100% effectively with an exposure of one hour, is .0046%. This is 4.6 parts per 100,000 of air. Various percentages of the flies were killed with lower concentrations of the gas.

The toxicity of HCN depends chiefly upon two factors: concentration and length of exposure. When liquid hydrocyanic acid gas or HCN generated from sodium cyanide by means of sulfuric acid and water is used, the initial concentration is high. With calcium cyanide these high concentrations are not reached due to the slow evolution. Theoretically, calcium cyanide at a rate of 1 lb. per 1000 cubic feet of air space should produce a concentration of 300 parts per 100,000.

It has been shown by actual experimentation that less than ⅓ of this amount is present in the air at any one time when this dosage is applied as a film on the floor. On this basis, the concentration from the house fly dosage—½ oz. per 1000 cubic feet—would not be more than 3.1 parts per 100,000 at any one time, at least near the floor, and would be less than that during most of the fumigation. The concentration near the ceiling and in the dust cloud itself was undoubtedly higher, as the flies were killed, but even here the margin of safety to man would be great.

Due to its great properties of diffusion, HCN soon becomes dissipated even in comparatively tight buildings. It was largely due to this reason that HCN was not successful as a war gas. The danger due to the presence of gas in rooms fumigated at the low dosages recommended at the time of airing out would be very slight.

Since the concentration of the gas near the floor is never high except for a very brief time, this increased the margin of safety still more.

In the Journal of Hygiene Vol. XXI No. 3, May 1923, Liston & Goré state: ". . . . it is difficult to obtain a sufficient concentration of the gas in the open air to poison men. It is pointed out that this experience accorded with that obtained during the war when hydrocyanic acid gas was used as a poison gas. It was stated that men are comparatively less susceptible to the poison than animals. Birds, for example, are very susceptible. Among mammals, dogs are killed in half an hour when exposed to about 8 parts of gas in 100,000 parts of air; cats require 12 parts; rabbits, 15 parts; rats, 20 parts to kill them; while goats and monkeys require nearly 25 parts. A man requires at least as much as a monkey to kill him." According to this it then requires several times as great a concentration of the gas to kill goats, monkeys and probably man as to kill flies.

Liston and Goré further state: ". . . . In low concentrations the gas causes a very disagreeable sensation in the throat and eyes so it is avoided by persons brought in contact with it. A man becomes unconscious only when exposed to higher concentrations, and, if the concentration which just causes unconsciousness is not increased, a comparatively long latent period supervenes before death. A person who becomes unconscious when exposed to moderate concentrations of hydrocyanic acid gas recovers rapidly when placed in the open air. The gas acts much like an anaesthetic such as chloroform. However, exposures to high concentrations may cause instant death, probably through action on the heart."

If slight effects are ever felt when handling the calcium cyanide they can be counteracted by occasionally inhaling ammonia or ammonium carbonate.

In fumigating the stores six mice were killed by the one ounce dosage in one room, one in another and still another in a third room. Two mice were killed in one store with the one-half ounce dosage. One rat was killed during the tests at the laboratories. The control of rodents can be facilitated by distributing some of the dust near the places where they are or may be concealed without in any way reducing the efficiency of the housefly control. Bats were also quickly killed.

While the figures of paragraph 3 under "Discussion" are only approximations, they show that, when the ½ oz. dosage is used, the concentration of gas required for the 100% kill of flies as derived by DeOng does not occur near the floor for a very long period at least and then possibly not uniformly. The gas, however, does become concentrated in the places where flies congregate for the night and if the rooms are reasonably tight will go above the 3.1 and probably above the 4.6 parts per 100,000 of air since they are effectively killed.

A dust gun may be used in applying the dust but it is not necessary. In case a dust gun is employed it should be thoroughly cleaned each time after it is used in order to prevent corrosion.

Domestic animals were never kept in the buildings during any of the fumigations and *fumigations should never be conducted with these present.*

That the greatest kill occurred in the first half hour was shown from observations made through the windows. Where conditions are such that only a few hours are available for fumigation, exposures of two hours for large rooms should give good results.

Conclusions

1. The experiments reported indicate that at least for the conditions that prevailed at Clemson College, S. C., during the last summer, the dosage of calcium cyanide needed in housefly fumigation ranges around ½ ounce per 1000 cubic feet, being slightly less in large rooms with very little leakage when fumigating at night when the flies are in the upper parts of the rooms and more as the amount of leakage increased, the increase being greatest in the smaller rooms. During the day the flies are likely to be in lower and more protected places and an increased dosage may be necessary especially for small spaces. Very large rooms even with considerable leakage can be successfully fumigated with the ½ ounce dosage, but smaller rooms of similar structure often required the one ounce dosage and sometimes more. It is believed that a dosage will have to be derived for each situation according to size and shape of the room, the amount of leakage in the walls and perhaps other factors. The ½ ounce dosage should prove a good basis for the first estimate with conditions similar to those in these experiments.

2. The margin of safety seems to be very great both from the practical and from the theoretical standpoint. Dosages higher than one ounce per 1000 cubic feet would probably never be warranted and should not be used unless further tests indicate them to be practical and economical.

3. Domestic animals should not remain in the rooms being fumigated in spite of the fact that the concentration of the gas might not constitute a lethal dosage. Canaries, however, would probably be killed while dogs which are very susceptible to HCN also might be. Rats, bats and mice were killed in the experiments.

4. Fumigations at night are usually more effective and more convenient.

5. Better results were usually secured in experiments where the cloud method of application was used rather than the film method.

6. Scattering some of the dust around places that may conceal rodents will give better kill of rats and mice and will not decrease the control of the houseflies.

7. Care should be taken in handling the calcium cyanide to prevent loss of the gas and to prevent corrosion of metal surfaces with which the dust may come in contact.

8. This method of housefly control is especially useful in large rooms such as dairy barns, stables, stores, bakeries, packing houses, store-rooms and in many other places where other methods of control are not practical and economical.

9. While preliminary tests showed that this method might be applicable to household use under certain conditions, it should not be recommended generally for this purpose. The possibilities of unfortunate circumstances arising from placing the material in the hands of people unacquainted with the nature and use of poisonous insecticides is far too great to warrant its recommendations for this use.

MR. PEREZ SIMMONS: Are there any advantages in scattering the dust through the air to spreading it on the floor?

MR. C. O. EDDY: We seemed to get more effective control from using the dust. I don't know what all the factors involved are, but possibly there is more gas involved. Anyhow in the comparison of the different experiments we got better results from those.

MR. PEREZ SIMMONS: In using it in restaurants, wouldn't it upset the whole place?

MR. C. O. EDDY: In restaurants we usually do use it as a film on papers on the floor.

MR. G. A. DEAN: The Dairy Husbandry Department of the Kansas State Agricultural College has been practicing for some two months by using the dust in their big milk house. They simply close the building up tightly just a few minutes before they are ready to bring the animals in and start down at one end with the dust gun and go clear through to the other end. Then they bring in the milch cows. They don't sweep up the dust or anything. There is no inconvenience to any of the animals. The flies do not bother the animals.

Another interesting thing that developed there is that after they have opened the house and are in there milking the cows, the flies lighting on the walls and around are still being killed. I just suggest that there is an adsorption of gas by the plaster there, or by the wood, that is still killing flies after the place has been opened.

MR. C. O. EDDY: There is one thing I did not mention and that is in the fumigation in the dairy barn the cost was reduced by one-fifth or one-sixth in comparison to the use of pyrethrum which was used prior to the starting of these experiments, and so the dairy barns began to use the calcium cyanide entirely in place of the pyrethrum and did away with the use of the dust gun. We found it was not necessary, although it is perfectly all right to use it.

MR. C. A. WEIGEL: How long a barn was it?

MR. C. O. EDDY: About 60 feet long, I would say, and some 25 feet high.

MR. C. A. WEIGEL: Did you try it out on windy nights?

MR. C. O. EDDY: Yes, and especially in small buildings we had considerable difficulty; we had to increase our dust quite a little bit.

MR. PEREZ SIMMONS: Did you succeed in killing cockroaches in the restuarants with the one-half ounce per thousand cubic feet?

MR. C. O. EDDY: I don't know about cockroaches but I do know we killed mice, rats, dragon flies and bats.

MR. C. C. HAMILTON: In connection with some of the investigations going on in New Jersey, through one of the fellowships established by the Crop Protection Institute, I might say that the Walker Gordon Dairies have used the pyrethrum extract with kerosene and they feel it is commercially profitable to them to control flies in the dairy barn. They have three large establishments—one near New Brunswick, one in central New Jersey and one in Connecticut, I think. They feel it is of value to them. The work was done by Mr. Nelson and he has a very large amount of data, but unfortunately hasn't been able to present it.

MR. H. N. WORTHLEY: I should like to ask Mr. Eddy if he thinks treatment of dairy barns for houseflies will supplant or render unnecessary treatment of breeding places.

MR. C. O. EDDY: I discussed that point in the introduction of my paper. The treatment of breeding places is always necessary and will always be and should be given preference. We found at Clemson College this summer that the houseflies could not be cleaned up from that standpoint, and this method was adopted by the dairy farms and restaurants to take care of a nuisance that was not being taken care of otherwise.

PRESIDENT ARTHUR GIBSON: The next paper is by R. W. Leiby.

"COLD STEAM" SPRAYING MACHINES

By R. W. LEIBY, *Department of Agriculture, Raleigh, N. C.*

ABSTRACT

Orchard and field crop sprayers that break up a spraying liquid by steam generated in a steam boiler are described. A five H. P. boiler generates steam with a gasoline burner as the heat source. From 80 to 100 lbs. of steam pressure will break up a spraying liquid to the fineness of steam itself at the nozzle, the steam passing through a separate lead of hose and meeting the spraying liquid at the nozzle. Any degree of fineness or coarseness of the spray can be secured by regulating the amount of steam allowed to pass through the nozzle.

Ever since we have been using spraying machines to treat crops for insects and diseases we have been practically depending upon the single principle of forcing a liquid under pressure of from 60 to 400 pounds through a small aperture to produce a spray. Another principle—that

of breaking up a liquid by heat and the velocity of steam is used in the Cold Steam spraying machines to finely divide a spraying liquid.

With this principle in mind four spraying machines have been developed in which the writer has had a field trial and a consulting part.[1] Only those that break up a spraying liquid by steam will be referred to here.

Steam Orchard Sprayer

The steam orchard sprayer used was mounted upon an ordinary spraying chassis, a steam boiler of five H. P. capacity which is operated by a gasoline or fuel oil burner generating from 60 to 150 pounds of steam pressure, supplying the steam. Spraying is done satisfactorily at from 80 to 100 pounds steam pressure. The boiler is fitted with an injector. On the chassis are also mounted a 150 gallon wooden tank to contain the spraying liquid, a 25 gallon wooden tank to carry water for the boiler, and a cylindrical metal tank to supply gasoline or fuel oil under low air pressure to the burner. A compartment between the fuel and spray tanks and under the water container, furnishes space for a steam driven agitator.

Steam is generated to operating pressure within fifteen minutes in the boiler and conducted through one lead of hose to a venturi nozzle. The spraying liquid is "pulled" to the same venturi nozzle by the steam, where it is broken up into a mist as fine as steam itself, or into a coarse wet spray,—the fineness of the spray depending upon the amount of steam that the operator permits to pass to the nozzle. If approximately one part of water, as steam, is used to break up three parts of the spraying liquid, the resulting spray will be almost as fine as steam itself. In this event, one steam nozzle does about 90% of the work of two high pressure sprayer nozzles, in time consumed and area covered. The steam sprayer has the very decided advantage of, *first*, saving spraying materials, and, *second*, applying the spray where it belongs in uniform quantities. If about three times the above relative quantity of spraying liquid is permitted to pass to the nozzle, the spray will be somewhat finer than that secured by the average sprayer operating at 250 to 300 pounds pressure. Any degree of fineness or coarseness of spray is available to the nozzle operator by opening or closing a valve which regulates the amount of steam entering the nozzle near its aperture.

The spray escapes with enough force to carry the fog-like mist considerable distances. The enveloping character of the resultant mist

[1]Patents pending by the Cold Steam Corporation, Charlottesville, Va.

Cold Steam orchard sprayer (Upper figure)
Applying the dormant spray with the steam sprayer. A five H.P. boiler will allow operation of two nozzles.

Steam sprayer of the cart type. Only steam is passing through the nozzles (Upper figure).

Applying calcium arsenate in an oil spray to cotton.

covers both sides of the leaves as a fog would do, and settles so gently that no harm is done to the bloom even at its calyx stage. The temperature of the spray at twelve inches from the nozzle is slightly below that of the atmosphere.

Slightly more gasoline is required to operate the steam boiler than to run the average gasoline engine of a high pressure sprayer. This extra operative cost is more than compensated by the following advantages, *first*, absence of moving parts, *second*, absence of pump and gasoline engine and therefore a freedom of costly and vexatious delays, *third*, lower upkeep, and, *fourth*, a decided saving in the amount of materials used. If fuel oil is employed under the boiler, the cost of fuel is less than that of gasoline used in high-pressure-sprayer gas engines.

The first cost of the Cold Steam Sprayer is at present greater than that of the average orchard high-pressure-sprayer. It would appear, however, that the steam sprayer would give longer service. Moreover the uses of steam about the farm in connection with a movable spraying tank are varied. Among them are, cleaning vessels, applying a thin film of oil or paints to farming machinery or buildings for protective purposes, whitewashing or disinfecting buildings, or cleansing motors of grease.

Field tests conducted over a period of two years including the dormant and summer sprays, have shown that insecticides and fungicides can be applied by the steam sprayer as effectively as with the high-pressure-sprayer. Moreover this is accomplished by a saving of from 30 to 40 per cent of the spraying material because the spray can be controlled so as to prevent wastage by dripping. It would appear entirely possible to uniformly distribute a definite quantity of the basic insecticides and fungicides of a given formula upon an acre of trees, in half the quantity of water or carrying liquid, now required or used to distribute the same quantity of insecticides and fungicides by means of the pressure-sprayer. This has been done in the case of a dormant spray of lime-sulphur where the dilution was only one-half that usually made for the dormant lime-sulphur spray. Less than one-half of the usual amount of spray was applied per tree at the reduced dilution but with equally good results as when the regular amount was applied by the high-pressure-sprayer at the usual dilution.

Field Crop Sprayer

The steam machine has also been adapted to the spraying of field crops, though it has been used experimentally thus far only for the spraying of cotton. In this machine a four H. P. steam boiler is mounted

on a two wheel cart. Eight nozzles properly directed will envelop cotton three feet high in a mist of the spray.

The field crop sprayer was used in an effort to control the boll weevil on cotton. It was found that five pounds of calcium arsenate could be suspended in as little as five gallons of water, and the poison applied uniformly over an acre of cotton. Treating three rows at a time, an acre of cotton can be covered in fourteen minutes. It is well known that from 100 to 150 gallons of a spraying liquid are required to cover an acre of an average row crop such as irish potatoes using a high-pressure-sprayer, especially if it is desired to cover all parts of the plants. It appears therefore that the Cold Steam Sprayer would obviate the necessity for large amounts of water now used as a carrying medium in the spraying of truck crops when applying insecticides and fungicides by a pressure-sprayer.

MR. J. M. SWAINE: What is the cost of the four horsepower machine?

MR. R. W. LEIBY: It isn't on the market yet.

MR. W. S. HOUGH: Several years ago there was a machine placed in some of the Virginia apple orchards in which the atomizing was done by air. Judging from these pictures the type of spray was very similar. It used a small amount of liquid, and made a very fine mist. These machines were so unsatisfactory in controlling the codling moth worm that they did not prove practical at all and have been abandoned.

PRESIDENT ARTHUR GIBSON: The next paper is by R. W. Doane.

THE GENUS IPS ON THE STANFORD CAMPUS

By R. W. DOANE, *Stanford University*

ABSTRACT

Twenty years ago *Ips plastographus* was the only species of *Ips* to be found in this vicinity. Ten years ago *I. radiatae* was more abundant than *I. plastographus*. Today both of these species have been supplanted by *I. confusus*.

About 1903 G. A. Coleman began a series of studies on the insect pests of the Monterey pine (*Pinus radiata*) on the Stanford Campus and at Pacific Grove. As these insects were killing many trees he had a good opportunity to make careful observations on several of the bark beetles. In this list he mentions only one species of *Ips*, *I. plastographus*. The descriptions that he gives of the work leave no doubt as to the species that he was dealing with. In 1904 P. B. Powell used some of the bark beetles in some studies he was making on the wing development of beetles. In the paper giving the results of these studies he describes

the typical work of *I. plastographus* and makes no mention of any other *Ips* work.

When I returned to Stanford in 1905 I began a series of observations on these insects and during the fall quarter of each year since then I have had occassion to continue these studies in connection with a course dealing with forest insects.

In 1905 and 1906 the only *Ips* work that I found was the work of *I. plastographus*. About 1907 we began to find in the same trees work of another species of *Ips*. This work was easily distinguished from the work of *I. plastographus* because the brood chambers were more or less curved and the eggs were deposited in the nitches along the sides in groups, three or four in a group, instead of singly as in *I. plastographus*. Specimens of both species sent to Dr. A. D. Hopkins in 1908 were identified as *Tomicus* (*Ips*) *plastographus* and *Tomicus* (*Ips*) *sp.* We later learned that Dr. Hopkins gave this undescribed species the manuscript name of *Tomicus* (*Ips*) *radiatae*.

From 1908 this undescribed species kept increasing in numbers until in 1914–15, when F. M. Trimble did his excellent piece of work on these two species, they occurred in about equal numbers in nearly all infested trees. It was at this time that Hopkins published the name of the new species, calling it *Ips radiatae*.

About 1916 *Ips radiatae* began to become the predominant species and in a few years it had almost entirely supplanted *I. plastographus* although specimens of the latter species were still found now and then.

In the fall of 1921 we found our first specimens of *Ips confusus* on the campus. These were found in a small yellow pine that had been planted near a wood yard in the nursery grounds. Previous to that time this species had not been reported from the San Francisco peninsula but we had occassionally found examples of its work on slabs of yellow pine that had been shipped into Palo Alto for fuel. The winters of 1922, '23, and '24 were exceptionally dry and many of the conifers throughout the state suffered considerably on this account. The weakened condition of the Monterey pines on the campus made them an easy prey to the bark beetles and many of our finest trees quickly succumbed to these attacks.

The swiftness with which *Ips confusus* spread over the campus was remarkable. Within two years it was the predominant species. *I. plastographus* had entirely disappeared. *I. radiatae* was still to be found in the lower part of some trees where *I. confusus* was working in the upper part. Our examinations this fall, 1926, have revealed very few

I. radiatae, while *I. confusus* is abundant in all weakened trees and is killing the tops of some of them.

Observations made on other parts of the San Francisco peninsula seem to indicate that *I. radiatae* is fast crowding out *I. plastographus* and that *I. confusus* is becoming established in some other places. It should be remembered that all of the Monterey pines outside of the Monterey peninsula and a few smaller groves along the coast are trees that have been planted for ornamental purposes.

In the native groves in the Monterey Peninsula *I. plastographus* was the only species known until about 1908 when *I. radiatae* began to appear in considerable numbers, the two species working together in the same tree apparently in defiance of Jordan's law of geographic distribution. Time has shown, however, that this is only a temporary arrangement for *I. radiatae* appears to be gradually driving out the other species. *I. confusus* has not yet found its way to the Monterey Peninsula. It will be most interesting to find what happens when it does gain a foothold there.

The only explanation that I can see for this succession of species in these pines is that *I. radiatae* is able to establish itself in a tree a little earlier than *I. plastographus* and that *I. confusus* is able to maintain itself in trees that would repel either of the other two species. None of these bark beetles seem to be able to enter a strong, thrifty tree, but when the tree becomes weakened from any cause whatever, its power of resistance is lowered and it becomes prey first to the beetle that can tolerate the strongest sap flow. As the sap flow is diminished other species may follow, and, if there is enough cambium left for them to rear their young, they too may survive, otherwise they perish.

Will *Ips confusus* finally exterminate the other species throughout their whole range?

MR. J. M. SWAINE: I would like to ask Professor Doane which species caused the outbreak in the Monterey Peninsula.

MR. R. W. DOANE: *Plastographus* has been the most common species on the Monterey Peninsula until the past four or five years. *Radiatae* is fast taking its place, although both species are still found.

PRESIDENT ARTHUR GIBSON: The next is a paper by S. B. Fracker and A. A. Granovsky.

THE CONTROL OF THE HEMLOCK SPANWORM BY AIRPLANE DUSTING

By S. B. FRACKER and A. A. GRANOVSKY, *Madison, Wisconsin*

ABSTRACT

Calcium arsenate at the rate of twenty pounds to the acre dusted from an airplane over a mixed rugged forest was successful in killing the larvae of *Ellopia fiscellaria* attacking hemlock and balsam.

In July, 1925, the superintendent of Peninsula State Park, Door County, Wisconsin, noticed that a fine stand of hemlocks was turning brown. Upon closer observation he discovered that they were being defoliated by measuring worms occurring in enormous numbers.

The writers[1] investigated the conditions on July 17 and found that the measuring worms were occurring in all the other hemlock stands in the park, as well as in other parts of the county. As they were reaching maturity at the time, any control measures during the season of 1925 were out of the question.

When the adult moths were collected, September 10, they were promptly identified by Dr. H. G. Dyar as *Ellopia fiscellaria* Guenee.

Judging from the effects of these larvae, hemlock trees when completely defoliated, die without being able to put out a new set of leaves.

The state forester estimates the loss in 1925 at 6,000,000 board feet. At one point practically no hemlocks of any age are living on an area of over ten acres while a large proportion of those over about thirty acres additional have been killed. In the remainder of the park the infestation was less severe and the defoliation slight to moderate.

DESCRIPTION OF THE AREA

The State Park infested consists of a peninsula of 3,733 acres, about 6 square miles, extending into the waters of Green Bay. Along the margin of most of the peninsula is a flat about twenty feet above the level of the Bay, varying in width from a few feet to nearly one mile. Separating the flat from the rolling plateau, which constitutes most of the park, is a rocky bluff varying in nature from a gentle slope in some sections to a vertical escarpment of more than 200 feet at other points.

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[1]The authors gratefully acknowledge suggestions from Mr. B. R. Coad, Mr. J. S. Houser, Mr. T. R. Chamberlin, and Mr. O. I. Snapp, the personal counsel of Dr. S. A. Graham, and the cordial support of Commissioner E. S. Hall, Mr. C. L. Harrington, and Mr. A. E. Doolittle of the Wisconsin Conservation Commission. The authors represent the Wisconsin state department of agriculture and the Wisconsin agricultural experiment station, respectively. A more complete report of the work will be published elsewhere.

Except for 900 acres of clearings, the entire area consists of forest: hemlock, balsam, maple, elm, poplar and white and red pine and white cedar being the most important trees. A few roads have been built through the area, but these are mostly about a mile apart and the park administration has specialized on the development of trails and bridle paths. This is of particular importance when it comes to insect control work for it is entirely impractical to use land machines for spraying or dusting except for narrow strips along the few roads. The paths and trails are not wide enough for the purpose.

A more hazardous area for airplane dusting could scarcely be imagined, for it was necessary for the plane to work down into the valleys, climb out of them, dodge unusually tall trees, and dust the edge of steep bluffs.

Life History and Habits

The eggs are deposited singly or in small masses on hemlock needles and bark in the fall, mostly during the middle and later part of September, before the advance of cold weather. They are almost spherical with a round crown-like depression on one end, measuring about 0.6 mm.

In the first or middle part of June, the eggs hatch, and small pale green larvae with conspicuous dark markings begin to feed largely on hemlock and balsam foliage. The smallest larvae observed were about 3 mm. in length and 0.5 mm. in diameter. They feed from the middle of June to early in August, evidently requiring about from 1½ to 2 months of feeding, before reaching maturity.

Most of the larvae begin to pupate in the middle of August, although there is a considerable overlapping, for at the same time the half grown larvae were not uncommonly observed. The pupation period extends well into the first week of September, but the majority of the larvae pupate in the second half of August. The pupation takes place under the bark of and in crevices of hemlock trees. Only rarely pupae were found under the leaves on the ground near the trunks of the trees. The pupae are on the average 1.1 cm. long and 0.3 cm. wide. The color of pupae is light brown with speckled markings.

The moths begin to emerge in the first part of September and continue to appear until late in the month. The majority of adults emerge, however, in the middle of September, at which time the whole hemlock wood was swarming with the flying moths, especially at twilight and in the evening.

There is thus far little indication of the presence of natural enemies in adequate numbers. In September of 1925 and 1926 numerous pupae, as well as larvae have been found parasitized by a fungus, which

produced a conspicuous white mycelial growth over the pupae and larvae. Dr. R. Thaxter, on examining it, found that the fungus is "apparently the same as the chinch bug fungus *Beauveria* (*Sporotrichum*) *globuliferum* Speg." In spite of the fact that a considerable number of larvae and pupae were affected, the value of the fungus has so far been negligible, for the reason that it attacked the insects late in the season and was unable to reduce the pest sufficiently to prevent the outbreak the following year.

The writers discovered no important insect parasites.

Preliminary Tests

Forestry practices not offering any hope of an immediate protection of the hemlock stands which were threatened with total destruction, artificial measures were tried.

Preliminary experiments with a hand duster showed that the rate of 20 lbs. to the acre should give satisfactory results. Approximately this amount was used in the work of air plane dusting. As this dosage correlated with recommendations by those who had done airplane dusting over cotton and over fruit trees, that proportion was determined upon for the field control measures.

In a commercial forest the question might have arisen as to whether the cost of dusting would pay as an investment. The conservation commissioner, however, felt the responsibility of maintaining the beauty and recreational value of the park, and believed himself justified in trying to save the remaining hemlocks if at all possible. On this basis the authors recommended the use of an airplane for the work.

Airplane Employed

It was decided to secure the plane on a contract basis and bids were requested from all firms who were known to have had experience in dusting from the air.

The contract was completed with the Decatur Aircraft Company, Decatur, Illinois, at the rate of $4.00 per acre for the services of the plane only and the company secured Les. W. Smith, Springfield, Illinois, as pilot. Both pilot and mechanician had had cotton dusting experience. The plane used was owned personally by Mr. Smith and had been adapted for dusting immediately before the work was done.

The hopper occupied the entire compartment for the mechanician so that the pilot was alone in the plane during dusting. The hopper would hold about 350 pounds of calcium arsenate, but after several

trials of different amounts, ranging from 200 to 300, a load of 250 was found both safe and convenient.

Agitation was secured by a small air propeller mounted on the lower left wing, driven by the airblast from the plane propeller and geared to the agitator in the hopper.

The dust was released by pulling a lever in the cockpit which opened a door in the floor of the hopper 27″ x 4½″ (later made 7″) in size.

During the eight flights on July 13 and 14, the method of covering the area used in cotton dusting was employed. That is, the pilot flew over a strip of forest releasing the dust and then returned parallel with the white strip of arsenate he could see on the trees. It was found that adequate dosage could not be secured in this way. It took six miles of flight with the hopper open to release the 250 pounds, the first 1,750 pounds covering 405 acres (4.3 lb. per acre).

The first improvement in the plan consisted of consolidating the areas and redrawing the map to show nine dusting plots instead of twenty. These nine had definite boundaries such as cliffs, clearings, and roads, which could be quickly recognized from above and each had one or both dimensions at least 60 rods long.

A second improvement to secure better dosage was a change in the hopper. The plane had in each case returned to the landing field with at least 50 pounds of dust remaining in the hopper. An extra partition was then built to cut off the lower rear corner of the hopper and it resulted in release of the full load.

As a third improvement, the opening thru which the hopper discharged was enlarged from 4½ to 7 inches in width. By keeping it wide open to this extent while the plane was discharging, the dust was released in four miles of flight instead of six as before. Finer distribution also resulted, as a larger quantity of dust struck the ventura and the under side of the plane and broke into a finer cloud than before.

Sixty-three flights were made, each load being 250 pounds, except in the first eight flights, on which 200 to 300 were tried, and the last three, when 275 were carried.

Each round trip, including loading, occupied about fourteen minutes, at times as many as five loads (1250 lbs.) being distributed over sixty acres of forest in one hour.

Taking the work as a whole, it may be of interest to note that the plane flew 252 miles of active dusting, about 100 miles while turning around after each strip, and over 500 miles from and to the loading field.

The material employed was in the main, Corona calcium arsenate, a total of 14,500 pounds without dilution with a carrier. In one section, 1,000 pounds of Niagara calcium arsenate was used.

Observations

The dust distribution could be very readily determined on almost any deciduous leaves, as well as hemlock needles. When evenly distributed at twenty pounds to the acre, it could be seen at a glance on the leaves of such trees as basswood, oak, beech, and maple and such undergrowth as dogwood, wild currant, fern and wild strawberry.

The number of dust particles per hemlock needle was of special interest. Accordingly, an effort was made to determine the distribution of dust on hemlock foliage. Naturally, it varied considerably, ranging from 0 to as many as 20 per one needle. Most of the needles had from one to six particles per needle.

It is of interest to note that the dust particles did not adhere well to the deciduous foliage. Upon shaking or even touching the leaves many particles fall off the foliage. Evidently there was lacking any electrical attraction between the foliage and the dust particles.

The swirling motion noted so often in connection with cotton fields is probably due to the interaction of the propeller blast, the ground, and the cotton plants. In the case of forest work, the ground is not near enough to cause air eddies in this way and there was no tendency for the dust to attach to the under sides of the leaves. It descended in about 20 seconds, straight down on calm days, and diagonally when there was a slight wind. An 8 mile breeze did not interfere with the work, but 10 miles per hour caused too much drift.

Larvae Died Within 24 to 48 Hours

In order to determine the mortality of worms in the forest after the airplane dusting several methods were used.

When twigs are lightly shaken, the larvae invariably hang on silken threads and their number on a given twig can easily be detemined by comparison with similar twigs in dusted areas, or before and after dusting. The following table will illustrate the use of this method in showing the efficiency of dusting the solid hemlock in the first plot covered; the 40-acre stand at Shanty Bay.

TABLE 4. INFESTATION BEFORE AND SIX DAYS AFTER THE DUSTING

No. of twig	Description of twigs	Number of living worms	
		Before dusting	After dusting
1	Twig 3 feet long	19	0
2	2 twigs 2 feet long	27	1
3	Twig 1½ feet long	11	0
4	Twig 2½ feet long	13	0
5	Twig 1 foot long	10	0
6	Twig 1 foot long	7	0
7	Twig 3 feet long	23	2
8	Twig 2 feet long	14	0
9	Twig 2 feet long	18	0

A better method for the determination of the mortality of the larvae was the use of square-yard pieces of muslin. Many such pieces of cloth were gently placed three days before dusting on the ground under hemlock trees of different sizes and in different densities of forest to determine the mortality before, if any, and after dusting. The height of the trees was recorded in order to estimate the relative area from which the larvae fell on the muslin. Approximately the same size twigs in the vicinity of these stations were shaken to determine the infestation before dusting. These stations were visited daily three days before, during and five days or later after dusting. No dead worms were found in a single instance before dusting. The worms continued to die for 5 to 8 days, but most of the larvae died between 24 and 72 hours after the dusting. The following representative table shows the death rate of larvae at "Hemlock Ridge," which was dusted July 17, 1926.

TABLE 5. MORTALITY OF LARVAE AFTER DUSTING

No. of station	Number of larvae found on cloth after dusting														
	July 18		July 19		July 20		July 21		July 23		July 24		July 25		Surviving on twig
	D.	L.	D.	L.	D.	L.	D.	L.	D.	L.	D.	L.	D.	L.	
1	52	1	33	0	—	—	Cloth disturbed and moved away about 25 ft. on July 20								
2	72	1	—	—	—	—	Cloth disappeared on July 19								
3	11	1	—	—	8	0	Closed on July 20								
4	15	0	—	—	11	0	2	0	2	1	2	0	1	3	3
5	33	0	34	0	28	0	2	0	Disturbed by animal. Closed July 23.						
6	12	0	26	2	33	0	Closed on July 20.								
7	9	1	6	0	8	1	Closed on July 20.								
8	1	1	5	1	3	0	5	0	0	0	1	0	0	0	3

As indicated, some trouble was experienced from animals in the woods which often disturbed the pieces of muslin at night.

From this table it is evident that in some instances as many as 97, 85, 73, 72, etc., dead larvae fell on the ground per square yard.

It is estimated that in a solid hemlock stand the mortality was 90 to 95%, while in the mixed forest not less than 80%. In only one area which consisted of young hemlocks over-topped by deciduous trees, and another which was dusted just before a rain, were the apparent results somewhat less than expected, with a mortality about 60%.

Cost

The contract called for a payment of $4.00 per acre by the Wisconsin Conservation Commission to the Decatur Aircraft Company, the Commission to furnish (a) the dust, (b) assistance in loading, (c) full instructions as to boundaries of the areas to be dusted, (d) a landing field. Fortunately a rental expense for the field was unnecessary, as it was offered by the owner for the purpose.

All areas dusted a second time were paid for at the same rate. The initial experimental flights thus proved expensive.

The commission informs the authors that including the preliminary flights the total cost was as follows:

Decatur Aircraft Company	$3,860.00
Corona Calsenate	957.60
Niagara Calcium arsenate	74.55
Freight and dray	112.90
Labor (approximately)	30.00
Total	$5,035.05

This shows an average total cost of $7.04 per acre for labor and material for the 715 different acres covered at full dosage. This amount is considered very moderate when compared either with the value of the trees saved, or with the cost of dusting from land machines.

Summary

The hemlock spanworm, *Ellopia fiscellaria*, while rarely reported as of economic importance, is able to destroy coniferous forests completely.

In the Wisconsin outbreak, hemlock and balsam suffered severely, and after they were defoliated the spanworms would feed freely on other trees. A single defoliation is fatal to hemlocks.

This species hibernates as an egg which hatches in June. Feeding continues until the middle of August or later, and pupation occupies about two weeks. The adults fly, mate, and oviposit in late September.

Airplane dusting proved a successful method of control and was used for 715 acres of infested forest. The area was extremely rugged and offered many difficulties and dangers.

Calcium arsenate dust, without dilution, at the rate of 20 pounds to the acre, gave an apparent mortality of 60 to 95 per cent.

An opening of 7 x 27 inches in the hopper was necessary in order to release the dust at the rate of 250 pounds in 4 miles. This covered a strip 1½ rods wide with satisfactory distribution.

Of various methods of determining distribution, observation of the dust on the leaves of deciduous trees, especially maple and dogwood, were most satisfactory.

Per cent of mortality was obtained (a) by comparison of branches before and after dusting, and (b) by catching dying and dead larvae on squares of convass left below the infested trees. The simplest form of check is a daily comparison of the dusted with the undusted areas as the work progresses.

No indication of electrification or other unusual adhesive qualities was obtained, and the arsenate did not reach the under sides of the leaves.

Mr. D. F. BARNES: I would like to know what the depth of the ventura section was beneath the hopper.

Mr. S. B. FRACKER: As I recall it, it was three inches. The details are shown in the paper.

Mr. D. F. BARNES: You used about four pounds to the acre when flying over the area once?

Mr. S. B. FRACKER: I didn't mean to give that impression. The pilot followed the method previously used in cotton dusting. He left too wide strips between the strips of dust. In cotton it seems the dust falls and then spreads out underneath the plants as a result of air currents. In the forest that does not occur. The dust fell directly and occupied a strip of from thirty to fifty feet wide.

The result was that when he, using his cotton dusting experience, came back parallel with his former strip, his strips were so far apart that he did not apply a sufficient amount of dust. The rate of four pounds to the acre also resulted when the hopper opening was four and a half inches wide instead of seven and a half. Then he was releasing his 250 pounds in six miles of flight. We reduced the strips to about twenty-five feet.

Going underneath sixty-foot trees where the dust had been applied at the rate of 20 pounds to the acre, you could see down on the foliage near the ground an adequate supply of dust at every step.

Mr. D. F. BARNES: In our work on Cape Cod we secured the same excellent coverage. After the dust cloud was caught by the tree tops it settled in a perfect fog covering everything in sight, and the coating

was very uniform from the top to the bottom of an individual tree.

Mr. H. T. FERNALD: I think in the past we have had more or less the general impression that a single complete defoliation of an evergreen tree would result in its death. May I ask if you got any evidence on that point from the defoliation of these hemlock trees?

Mr. S. B. FRACKER: That was our conclusion, that the trees which were completely defoliated did not come back. Where they were possibly 90 or 95% defoliated, there seemed to be some return, although the growth was retarded very greatly. Where the dusting was a little late this past summer in the most heavily infested areas, the trees were showing buds this fall as if they were going to come out very satisfactorily in the spring.

Mr. D. F. BARNES: This year we had very serious defoliation on Cape Cod by the gipsy moth. In many places the pitch pines (*Pinus rigida*) were completely defoliated. When these areas were visited in September many of the pines had a new suit of foliage so that it was difficult to tell those that had been defoliated from those that had not been damaged.

ADJOURNMENT: 12:05 p. m.

Friday Afternoon Session, December 31, 1926, 1:40

PRESIDENT ARTHUR GIBSON: The first paper on the program this afternoon is by W. P. Flint and C. C. Compton.

Mr. Flint read the paper.

A SUGGESTION FOR CONTROLLING THE LOCUST BORER, *CYLLENE ROBINIAE*

By C. C. COMPTON and W. P. FLINT, *Illinois Natural History Survey*

ABSTRACT

The Black Locust is one of the most valuable of the native trees growing in the United States. Many locust plantations have been started in Illinois, but practically all of them have been destroyed by the Locust Borer, *Cyllene robiniae* Forst., in most cases before the trees became of sufficient size to be used even for posts. During the past ten years, many experiments have been conducted to try and find a control for the Locust Borer. These have included most of the recommended practices, and many others. Experiments in poisoning the beetles were carried on for several years, at first with promising results, but in the other years, the results were largely negative. It is shown in the course of this work, that many of the female Locust Borers emerge from the tree, mate, and lay considerable numbers of eggs without having fed.

Banding the trees with various materials, particularly tanglefoot showed that the active beetles readily caught in the bands were not killed, and soon freed themselves of most of the tanglefoot.

During the past year, bands containing tanglefoot mixed with sodium fluoride and sodium arsenite have killed all beetles coming in contact with them. The

sodium arsenite-tanglefoot mixture, seems to offer promise of a practical method of Locust Borer control under certain conditions.

Sound Black Locust is generally considered our second best tree for fence posts in Illinois. The value of this tree has been recognized for a number of years and a score or more enterprising men in the State have in the past set out Black Locust plantations ranging in size from one to sixty acres. In nearly every one of these plantations, it would now be impossible to find more than a few sound posts in the lot. This is because of the ravages of the Locust Borer, *Cyllene robiniae*. In some of the worst infested plantations the trees have been entirely killed out with the exception of an annual growth of suckers from the trunk of the tree.

The results in these plantations in the northern and central parts of the State indicated that if we can not control the Locust Borer, we can not grow sound posts or, in most cases, any posts at all. Many sprays which have been tried as larvicides, or ovicides, have not proved successful and the problem seemed one of controlling the insect in the adult stage.

With the idea of poisoning the beetles, various baits were tried out during their active period in 1922. The temperature during this period was above normal and the weather clear and dry. It is in this kind of weather that the beetles are most active. Under these conditions it was found that the beetles fed quite readily on strips of fermented watermelon and cantaloupe rind which had been poisoned with calcium arsenate or arsenate of lead. It was also found that a bait composed of molasses, spoiled plums, bananas, and a little water which had been allowed to ferment was very attractive to the beetles. When this latter bait was poisoned with calcium arsenate a large number of beetles were killed. The addition of such materials as ethyl butrate, amyl acetate, anise and many others, did not add to the attractiveness of the bait.

The following year, 1923, these baits were tried out again and this time on a larger scale. However, the weather conditions were just the opposite those of 1922. The temperature was below normal and rain fell most of the time. Under these conditions the beetles were less active and were not attracted to the baits to any great extent. For this reason, baits did not seem promising. It was also found in cage experiments that it required three days to get a complete kill of the beetles with calcium arsenate, six days with lead arsenate, while the beetles lived twelve days in the check cages. The inefficiency of the poison baits was further demonstrated by the fact that the beetles were still able to lay eggs after feeding on the poison bait. When lead arsenate

was used the female beetles laid an average of 23 eggs over a period of three days. When calcium arsenate or sodium arsenite was used they laid an average of 17 and 21 eggs per female respectively on the first day and none thereafter. In check cages when unpoisoned bait was used the beetles laid an average of 88 eggs over a period of seven days.

In the course of this work, it was observed that the female beetles often emerged from its burrow, mated and laid eggs without leaving the tree for food. An experiment was run to further prove this point. The beetles used in this work were chopped out of the pupal cells in the tree. One female and two males were used in each cage and the number of eggs laid daily recorded. The average number of eggs laid by these beetles was 42.5. In every case the beetles laid the greater part of their eggs during the first two or three days that they were confined in the cage and none were laid after six days. This shows that the beetles are capable of laying eggs without feeding. Normally after laying the first lot of eggs they fly to the goldenrod and remain there to feed for a period of two or three days before returning to the trees to deposit eggs. How many times this operation is repeated we are unable to say.

The activity of the beetles and their habit of running up and down the trunk of the tree led us to believe that tanglefoot might be effective as a means of control. In the early work with tanglefoot it was found that altho the beetles did not avoid the tanglefoot and became smeared with it they were able, in most cases, to clean themselves, and were not killed. The idea of incorporating a poison in the tanglefoot so that in cleaning up the beetles would be poisoned was then tried. During the season of 1926, a series of experiments was carried out to determine the possible value of such a material. Arsenate of lead and calcium arsenate did not mix well with the tanglefoot. Sodium fluoride made a very good union with the tanglefoot but the poison worked too slowly on the beetle. However, a 50% solution of sodium arsenite unites excellently with tanglefoot, does not injure its sticking qualities and gives a quick kill of the beetles. The sodium arsenite, tanglefoot mixture irritates the feet of the beetle and they will proceed to clean themselves almost immediately upon coming in contact with it. In cage experiments the average life of the beetles was 15.1 hours when a mixture of one part of the 50% sodium arsenite solution was used in ten parts of commercial tanglefoot and 4.8 hours when the mixture was 1–5. The average life of the beetles was 7.4 days when straight tanglefoot was used, and 11.9 days when no tanglefoot was used. When used on trees

in the open, it was found that very few beetles escaped the poison tanglefoot band when placed around the tree at a point approximately five feet above the ground.

It was further demonstrated that the sodium arsenite mixture at the 1–5 strength affected the beetles in 20 to 30 minutes after they came in contact with it. In no case were any eggs laid in cages where this mixture was used. When the sodium arsenite-tanglefoot mixture was used at the rate of 1–10, a single egg was laid in one cage. When sodium fluoride was used at the rate of one part of sodium fluoride to ten parts of commercial tanglefoot the average number of eggs laid by each female was 4.3, when twice this amount of sodium floride was used the average was 1.7, when straight tanglefoot was used the average was 5.6 and when no tanglefoot was used, the average was 21.6. The beetles used in this experiment had been out and laying eggs a week or more before they were captured.

The comparatively short period of activity of the adult Locust Borer affords little time for experimentation in any one year. Much more work must be done before any definite recommendations can be made. However, it is felt that the sodium arsenite-tanglefoot mixture may prove of value, on this and possibly some other insects at least under certain conditions, and will certainly warrant further tests being made.

Mr. H. B. PIERSON: Did you state that when beetles come out they lay their eggs in the same tree?

Mr. W. P. FLINT: Not necessarily in the same tree, but as a rule they lay a certain number of eggs before they feed.

Mr. H. B. PIERSON: Would the tanglefoot get those beetles?

Mr. W. P. FLINT: We don't claim it would get all of them, but when they come out they run around over the tree for a certain length of time before they begin laying.

Mr. H. B. PIERSON: In what part of the tree are they laid?

Mr. W. P. FLINT: All up and down the tree, stuck into little crevices, deposited singly.

PRESIDENT ARTHUR GIBSON: The next paper is by J. S. Houser.

ELLOPIA ATHASARIA WALK., A LOOPER ATTACKING HEMLOCK[1]

By J. S. Houser

Abstract

This Geometrid looper appeared in hordes in 1925, attacking hemlock in eastern Ohio. A few other forest trees were injured. Defoliation killed hundreds of hemlocks—some large enough for saw logs. Scourge disappeared, 1926, probably as a result of the work of the fungus *S. globuliferum* attacking the over-wintering pupae.

September 14, 1925, the writer observed that the hemlock in the vicinity of East Liverpool, Ohio, was dying in great numbers. In this section of the state hemlock occurs as a mixed stand with beech, maple, oak, elm, etc., in some areas occasionally amounting to forty per cent of the stand while in still more restricted sections the stand is almost pure. The larger trees reach saw-log proportions and the species is considered one of the valuable trees of the area, not only from the utilitarian standpoint but from the easthetic as well. In the latter sense it is prized especially since it is the only conifer commonly found, and thus contributes much to the beauty of the landscape, particularly during the winter months. The dead and dying trees, even in the distance, were very apparent as one drove along but when a critical examination was made of roadside trees the cause of the trouble was not so easy to determine since the larvae, which at that time were abundant, present a most excellent example of protective resemblance and coloration. Hemlock was the chief host but red oak, white oak, beech, soft maple, and ironwood were found also to be injured to a slight degree.

The concensus of opinion of farmers and others seemed to be that the hemlock had been ailing for two or three years but no one with whom I talked had ever observed feeding larvae. Most seemed to think that a disease, such as chestnut blight, or perhaps some obscure scale insect, was responsible for the trouble and that the hemlock, like the chestnut, was doomed, as indeed it seemed at that time to be. The older residents could not recall a time previously when hemlock had not been healthy in that vicinity but one man remembered that some fifteen or twenty years ago practically all the hemlock in an area south of Wheeling in West Virginia had died. In passing it may be well to note that in northern Michigan and in a restricted section of Wisconsin similar injury to hemlock has been reported recently but a different species, *Ellopia fiscelleria* Gn., is the causative agent.

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[1]Determined by Dr. Carl Heinrich.

Athasaria in the larval stage is typical of the Geometrids in form and manner of locomotion. When mature the larva is about 30 mm. long and 3 mm. broad. It is almost cylindrical though the cephalic end is slightly narrower. In color it very closely resembles a hemlock twig. Since the writer has been unable to find a description of the larva one is appended hereto.

LARVA. 30 mm. long, 3 to 4 mm. broad, cylindrical and slightly narrowed toward the cephalic end. Head distinctly bi-lobed, the ground color light pearl but this is almost obscured by many irregularly sized brown spots, the larger of which are so very dark brown they are almost black. Thoracic legs and the legs borne on the sixth abdominal segment are honey yellow and the anal legs or claspers are greenish-yellow, abundantly dotted with irregularly shaped dirty-brown marks. The spiracles are jet black. Beneath, the caterpillar is very pale greenish-white marked by five broken, rather wavy narrow brown lines extending from the third pair of thoracic legs to the first pair of abdominal legs. At the outside of the anal margin of each abdominal segment is an obscure lemon yellow spot. The sides of the body are much darker, the color being due to wavy lines, some very narrow, others broader, the predominating colors being very dark brown and reddish brown with now and then a touch of white. The dorsum is much lighter in color, each segment prettily marked by indistinctly designated yellowish and light brown areas intermingled with more distinct white and yellow areas.

The caterpillars start their work in the tops of the trees and gradually extend the injury downward, finally reaching the bottom. Some needles are consumed, others cut off and since the insects spin some silk the cut needles collect therein, and the tree gradually assumes a very untidy appearance. The top of the tree dies first and as defoliation continues the lower branches sucumb. One complete defoliation kills the tree. Soon bark beetles and other insects invade the wood and unless cut within a few months the tree is a total loss.

In so far as is known there is but one brood per season, the caterpillars reaching maturity about mid September. The winter is spent in the pupal stage above the soil amid the debris of the forest floor in the shelter of fallen twigs, crevices in the base of trees, etc. Dry rather than moist situations are chosen. Contrasted with *fiscelleria* the hibernation of this species is different since the former, according to Prof. R. H. Pettit, passes the winter in the egg stage on the needles of the host. The light-brown dark-mottled pupae which vary in length from eleven to fourteen mm. are unprotected in so far as a cocoon is concerned and are only slightly secured among the debris by scattering silken threads tangled in two sharp curved spines at the anal tip.

As to control, it is a pleasure to record that artificial measures were unnecessary, since the outbreak terminated this season as suddenly as

it had appeared. Careful searching in September of this year in the areas where the larvae could be collected by the thousand last season resulted in the finding of only two larvae. In so far as could be determined, the fungus *Sporotrichum globuliferum* brought this about since in early spring the mycelium covered pupae could be found by the hundred, and no parasites were reared from the mass of material collected for observation.

By way of conclusion we might ask, just what were the contributing conditions which enabled an obscure native insect to suddenly assume the proportions of a scourge, but that would take us into a field which we as entomologists have failed to develop and until we secure more fundamental information concerning the underlying principles of insect activities such a discussion would have little actual value. We can, however, draw the lesson that every bug which feeds on any plant or animal of value has in it potential possibilities for destruction and no matter how insignificant it may seem at one time it is to be regarded with suspicion.

PRESIDENT ARTHUR GIBSON: Mr. R. T. Webber will now read a paper.

SOME IMPORTANT ECONOMIC INSECTS OF CENTRAL EUROPE

By R. T. WEBBER, *U. S. Bureau of Entomology, Melrose Highlands, Mass.*

ABSTRACT

Remarks on several insects of economic importance observed in the forests of Central Europe.

The recent agitation against one of the Federal Horticultural Board quarantine regulations[1] concerning the importation of certain plants into the United States to prevent the introduction of insect pests indicated clearly that doubt existed in the minds of many people as to the necessity of such rigid restrictions. While it is undoubtedly true that the facts warranted the ruling, the objections raised are not at all surprising, because most people pay little attention to insect pests unless they experience loss or see excessive damage. Printed matter or hearsay evidence is not convincing. Few of the multitude of Americans visiting foreign countries each year ever witness the havoc wrought by certain insects which at the present time have not reached our shores. Those who have done so will very likely share the views held by those responsible for our crop protection.

[1]Narcissus bulb quarantine order No. 62, Federal Horticultural Board, U. S. D. A.

The writer, having been detailed by Mr. A. F. Burgess in charge of Moth Work, Bureau of Entomology, to make in foreign countries investigations on the gipsy moth, has had occasionally an opportunity to observe some of the more common insects of the European forest.

To the men engaged in the European Investigations of the gipsy moth (*Porthetria dispar* L.) there is scarcely anything more discouraging than the failure to locate suitable infestations for parasite work. Frequently, even when supplied with apparently the best information, the trail ends in some obscure forest where no gipsy moths are present. Unfortunate as we consider ourselves at such times, there is, usually, certain recompense because some interesting insect is concerned.

While scouting in the northwestern part of Poland for gipsy moth infestations the writer first saw the effect of one of the most destructive of all forest insects, the Pine Moth (*Panolis griseovariegata* Goeze). This insect is a great devastator, and there seems to be ample proof that two years of successive defoliation will kill the trees. The reports which have reached America concerning the seriousness of its depredations are not exaggerated. In fact I know of few other insects which can be held solely responsible for the killing of forests. Usually there is a combination of insects or insects together with some other factor, perhaps natural or perhaps a condition brought about by man.

During my trip we passed through many acres of what had been a most beautiful forest of *Pinus sylvestris*. The rich sandy loam, in most part free of undergrowth, gave rise to tall stately trees 60 to 80 feet in height. Hundreds of these now stood apparently lifeless, destitute of foliage, or, what appeared even worse, crowned with remnants of weakened needles. Such was the condition of the forest in the ravaged area. This was in 1925, the infestation having reached its height in the previous year, after a two or three years' invasion. The area infested by *Panolis* in northwestern Poland was more than 50,000 acres.

An infestation of this species was reported by Summers[2] in 1913 as occurring near Eberswalde, Germany. Nearly 15,000 acres were completely defoliated and a large percentage of it killed.

There is also very good reason for believing that this is the insect reported by Hyslop[3] as devastating enormous tracts in East Prussia during 1923–24.

I have no first-hand information concerning the natural enemies of *P. griseovariegata*, but I know that some studies were made by Prof.

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[2]Unpublished Gipsy Moth Laboratory Records.

[3]Insect Pest Survey Bul. 4, pp. 247, 287, 320. 1924.

Mokshetsky[4] who is soon to publish them. Baer[5] lists 11 species of Tachinid flies and Ruschka and Fulmek[6] 6 species of Hymenoptera as having been bred from *P. griseovariegata*.

As far as I was able to learn no artificial control was practised. I know that there was no spraying, and I saw no banded trees. The invasion was said to have been brought to a close by an epidemic of fungus (*Entomophthoreae*) which, according to several observers, destroyed most of the caterpillars within a few days.

The life history of *Panolis griseovariegata* Goeze, which has been given me by Dr. Stefan Keler,[7] is as follows: Adults are in the field from the end of March to the middle of April. The eggs are deposited in rows on the under side of the needles, the larvae hatching in about two weeks. The larval period extends to about August 1st, when the fully developed larvae burrow a few inches into the ground and pupate. There is but one generation, the species passing the winter as pupa. The food plants are given as various species of pine and fir.

In this same forest there was also a large infestation of the Pine Shoot Moth (*Evetria buoliana* Schiff.). In most part its attack seemed confined to the plantations of smaller growth, containing trees of about 20 to 30 feet in height, although occasionally the older trees were infested. In one plantation of several acres every tree examined had the deformed terminals characteristic of the injury caused by *buoliana*. This insect, although of much lesser importance than *Panolis griseovariegata*, rarely if ever causing the death of a tree, must be regarded as a noxious one. This is particularly true in the present case, where the forest is already filled with a growth weakened by another cause. No control measures were used against this insect.

In the same forest adults of the nun moth (*Lymantria monacha* Linn.) were occasionally found. At times this moth is very injurious to both coniferous and deciduous growths. Few insects have a more unenviable reputation than this one, and much has been written regarding its depredations. A good many of the entomologists and foresters with whom I have talked consider it the most destructive pest of the forest. In Europe the enormous losses of timber and expenditures for control are greater with this insect than with any other. I have passed through

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[4]Zaklad Ochrony Lasu i Entomologji, Skierniewice, Palac, Poland.

[5]Die Tachinen, Schmarotzer der Schädlichen Insekten, p. 182 Verlagsbuchhandlung, Paul Parey, Berlin 1921.

[6]Zeitschrift für angewandte Entomologie, vol. 2, part 2, p. 407, Aug. 1915. Verlagsbuchhandlung Paul Parey, Berlin.

[7]State Institute of Scientific Agriculture, Bydgoszcz, Poland.

many forests where this insect had been rampant at previous times, but I have never happened to be present during an invasion.

Mr. Crossman, whom I assisted in 1923–24, has told me of a heavy infestation of the nun moth that he witnessed in the vicinity of Zittau and Obersdorf, Germany. The forests throughout this section are mostly pine (*Pinus excelsa* and *P. sylvestris*), there being also considerable birch and beech (*Betula alba* and *Fagus* sp.). The injury to the pine, especially the *P. excelsa*, was such that the major portion of it had to be cut the following winter. The deciduous growth did not suffer so severely. According to reliable authorities the infestation began in 1907, but did not reach alarming proportions until 1921 when the infestation was augmented by a great flight of moths from the east.

During Mr. Crossman's visit, which was in July, 1922, the insects were at their worst and acre after acre of the forest stood defoliated. Enormous numbers of caterpillars were crawling on and beneath the trees, and under certain trees lay thousands of them, dying from starvation. There seemed very little likelihood of a severe infestation for 1923.

The only method of control practised during the outbreak was by the use of "raupenleim," a somewhat sticky tree-banding material. Because of the huge area infested and the lack of necessary funds, only a portion of the forest was banded. The trees that had received this treatment were saved as nearly all of the eggs were deposited low down on the tree trunks—in many instances close to the ground.

Studies were made of the outbreak, by government men, but I do not know of their publication. Of the natural enemies of the nun moth the tachinid *Parasetigena segregata* Rond. and the Hymenopteron *Apanteles fulvipes* (Hal.) were found very frequently in 1921. The parasitism by these species in 1922 was negligible. According to Baer,[8] at least 12 Tachinids and 10 Sarcophagids are reported to have been bred from this host. There is also a list of 15 Hymenopterous parasites bred by Ruschka & Fulmek.[9]

The life history of the nun moth, which has been given me by various authorities in Europe, is as follows: The adults deposit their eggs on the bark of the tree, preferably the trunk, in July and August. Hibernation is in the egg stage, the larvae hatching about April 1st. Sometime in June and July they reach their full larval development and pupate above the ground. The pupal stage lasts about two weeks. The principal foods of the larvae are spruce and pine although oak, beech, and other deciduous plants are acceptable.

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[8]loc. cit., p. 179. [9]loc. cit., p. 407.

Before leaving this locality we were advised of a *dispar* infestation at Smogulec, near Bydgoszcz. We visited this town later, only to find that the so-called *dispar* were in reality the Satin Moth (*Stilpnotia salicis* L.). The infestation was confined to the roadside trees (*Populus pyramidalis*). These trees, large and healthy, which had been stripped several weeks previously, were again in full foliage when we arrived, and apparently were in good condition.

Several other small infestations of the Satin moth have been observed in other localities but none of them seem to have caused any serious injury. In no instance have I heard of any control methods being used to combat *Stilpnotia*.

About the middle of May, 1923, Mr. Crossman and I were in Hungary. The gipsy moth season was rapidly approaching and there seemed little prospect of finding anything suitable for our work. We were about to leave for other parts, when word was received of an infestation of the gipsy moth near Kaposvar, West Hungary, a considerable amount of stripping having been noted. Mr. Josef Ujhelyi, of the Hungarian National Museum, accompanied us on this trip.

Arriving at Kaposvar, we were met by a guide and conveyance. For some distance before we reached the forest we could see that a large part of it was defoliated and visions of trees, swarming with caterpillars were before us. We were doomed to disappointment, however, for the devastators were not *dispar* but the Cockchafer, *Melolontha vulgaris* L. A conservative estimate of the defoliated area would be over 50 acres. The entire place was teeming with beetles, and one could have easily picked up a quart of them in a few moments. Lying on the ground were many dead ones and some of them were collected for possible parasitism. These were held for some time and several Sarcophagid and one Tachinid puparia were secured. No adults issued and their identity remains unknown.

I have seen the work of *Melolontha vulgaris* in one locality or another every year that I have visited Europe. On one occasion, at Nyiregyhaza, East Hungary, a small area of perhaps twenty acres of oak growth was completely defoliated in 1923. The limits of the infestation, as shown by the defoliation, although unrestricted as regards food plants, were as clearly defined as if laid out by a surveyor. The adjacent growth was in full foliage.

The behavior of the insect is not always as I have pictured. Quite often it happens that the infestation is confined to a limited number of trees or even to a single tree. An instance of this sort was reported

by Dowden[10] at Bilky, East Czechoslovakia, in 1925. So abundant were the beetles in certain localities that often farmers passing by the infested places would stop, fill their hats with the beetles and carry them home to feed the ducks. In the forest, however, they were extremely scarce.

The same year an infestation of this species was noted at Debreczen, East Hungary, by Jones and Ujhelyi.[11] In this case the infestation was limited to the trees which adjoined a small cultivated area, the forest itself being quite free.

Although I have spoken only of the adult of *M. vulgaris*, it must be remembered that it is not in this stage, but in the larval stage, that most injury is sustained. Root crops of all descriptions are attacked and often suffer great losses.

The natural enemies of this insect are said to be few. Baer[12] reports but one Tachinid parasite, although two other closely allied species of *Melolontha* have given several others.

The life history of *Melolontha vulgaris* is as follows· Adults appear in May and June and deposit their eggs a few inches below the surface of the soil. The larvae hatch in two weeks or so and feed on the roots of various plants. They develop slowly, not reaching their full development until the third or fourth year. The pupal stage is passed deep in the ground and lasts for some time.

No satisfactory measures for control seem to be practised. Ploughing often turns up the larger grubs, which are destroyed, and the collection of adults for a few cents per quart is also resorted to.

Prof. Silvestri, of the Entomological Experiment Station, Portici, Italy, considers *Tortrix viridana* L. the very worst forest insect. It is quite possible that not all European entomologists would agree with him. There seem to be, however, few, if any, insects, periodic in their abundance, more commonly observed than this one. In going over my notes for the last four years, I find no less than 14 infestations recorded, few of which were in southern Europe.

In 1923, when returning from an unfruitful search for *dispar*, in Roumania, acre after acre of forests partially defoliated by *Tortrix viridana* could be seen from the train windows. The same year at Debrezcen, Hungary, there was a heavy infestation, the entire forest being infested and a certain portion of it was completely defoliated.

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[10]Unpublished Gipsy Moth Laboratory Records.

[11]Unpublished Gipsy Moth Laboratory Records.

[12]loc. cit., p. 187.

It is interesting to note that the attack of this insect was followed by one from *dispar*. In two sections of oak growth, many trees stood practically defoliated for more than a month.

Debreczen being one of the points where the gipsy moth parasite work was established we were enabled to follow the progress of this infestation. There was no attempt to study its parasites, simply field observations being made. The infestation of 1924 was much lighter than that of the preceding year, the trees suffering only partial defoliation. In 1925 the species was scarcely noticeable unless one were searching for it. During 1926, specimens of either *T. viridana* or *P. dispar* were rarely to be found in this forest.

The life history and behavior of *Tortrix viridana* are similar to those of our own oak Tortrix (*Archips argyrospila* Wlk.). The species hibernates in the egg stage, the larvae hatching about April. Full development of the larvae is reached toward the end of June. The pupal stage lasts about two weeks, the adults emerging and laying their eggs on the bark of the trunk, and in lesser numbers on the limbs of the trees. The food plants are principally the various species of Quercus, besides many other species of deciduous trees.

In no forest that I have ever visited have I seen any control measures practised against this insect. Its natural enemies are numerous. A good account of these, with notations, as well as with much other information recently appeared in a publication by Prof. Silvestri.[13]

While investigating a gipsy moth colony near Cracow, Poland, we chanced upon a most serious outbreak of the Coniferous sawfly, *Diprion pallidus* Klug. It was of particular interest to us, as this insect was the overwintering host of *Sturmia gilva* Hartig, one of the gipsy moth parasites which we were seeking.

The oberforster of that section, having guided us to the locality where *dispar* was most abundant, suggested that we visit the nursery. Here were found many pine seedlings in very poor shape, and a few of them dead. Sometimes there would be from one to a dozen cocoons, either stuck to the plant or in the ground at its base.

The main forest, of *Pinus sylvestris*, many acres in extent, adjoins the nursery, and was heavily infested with this insect. From the nursery one could readily distinguish the trees that had been attacked by *pallidus*. There seemed to be every degree of feeding, a few trees were entirely defoliated (apparently dead), and the foliage of most of

[13]Contribuzioni alla conoscenza dei Tortricidi Delle Querce (1–11) Portici, Stab. Tip. Ernesto Della Torre, 1923.

the others appeared thin. Occasionally there was one that gave no indications of having been fed upon.

This was in 1924. The following year, the sawfly was again present and in such numbers that there was no difficulty in obtaining enough cocoons for our parasite work. I know of no better way to illustrate its abundance than by stating that five 100 lb. grain sacks were filled with the small cocoons of this sawfly within a few days notice. Furthermore, a month previously, in this same area, an equal quantity was collected by the oberforster for other purposes.

As is often the case, the next year our duties were elsewhere and I am unable to say whether the trees recovered or died and were felled. In either case the trees obviously suffered a severe setback during these three years.

In recent years a good deal of our gipsy moth parasite material has come from the Pandor forest, Baja, south Hungary. The forest land in this vicinity is of mixed growth, a large percentage of which is willow. In May, 1925, the willows over a large area were infested with one of the spittle insects (*Aphrophora salicis* de Geer). Scores of the trees were white with the froth-like exudation of these insects, which was dropping from the trees to such an extent that pools formed beneath them. So extraordinary in abundance was this insect that the *dispar* deserted the trees for other more desirable species. In 1926 the infestation was still present, but in much lighter proportions.

The extent of the injury caused by *salicis* was difficult to estimate. I do not believe that any of the trees were injured beyond recovery, but the brown and shriveled foliage indicated considerable damage.

One warm, humid morning as we were passing along the wood road that led to the insectary, we noted a peculiar pungent odor which my assistant immediately recognized as belonging to the blister beetle *Lytta vesicatoria* L. It did not take us long to locate them, as several partially defoliated ash trees gave evidence of their presence. This occurred in June 1925; one week later none of the beetles could be found.

In 1926 these beetles were again present in the same locality, appearing in about the same abundance, stripping a few trees and then disappearing. The trees which were attacked recovered rapidly and seem unaffected.

Species of the genus Hyponomeuta (Apple and Cherry Ermine Moth) are frequently seen in such numbers as to attract attention. Probably *Hyponomeuta malinellus* Zeller and *padellus* L. are the most important. Partial and complete destruction to the foliage of fruit trees has been

observed in Roumania, Bulgaria, and Hungary. In no instance have any of these observations been followed up, and the extent of the injury sustained remains unknown. A rather detailed account, including the life history and habits of the Ermine moth, has been published by Prof. P. J. Parrott.[14]

Deserving of much fuller details than my observations are able to supply, are such pests as the "forest-gardener," *Tomicus piniperda* L., the "Oak Procession Moth," *Cnethocampa processiona* L. and the "Lackey Moth," *Malacosoma neustria* L. In the pine forests of Poland I have seen the ground strewn with terminal shoots, the work of *T. piniperda* and often in the oak forests of Central Europe innumerable masses of old molted skins were indicative of a former abundance of *C. processiona*. *M. neustria* is invariably present in more or less abundance, either on fruit or on forest trees.

The Coleopteron *Anisoplia austriaca* Hbst. is a common insect, and in 1926 was to be found in many grain fields throughout Central Europe. It is not thought to be very injurious.

All of the insects mentioned have received more or less attention from various authors. Another species less frequently encountered, which injures man and animals, is the Columbacz midge (*Simulium columbaczense* Schoenbauer). It has an evil reputation, and the economic losses caused by it are considerable. It is even said that it has caused the death of children.

In southern Hungary, and especially along the lower Danube Valley, it is very common. Its life history, which is similar to that of other related species, has been published by Dr. Horvath.[15]

A unique method was used by the wagon men to protect their oxen from this pest. Slung from the tip end of the pole that separates the animals was an iron pot from which arose a black smudge. In spite of the fact that the animals' noses and eyes were continually filled with smoke, it was apparently less annoying to them than were the flies. Evidently they were accustomed to it. We were told that the fuel used was corn-cobs and husks, soaked in tar.

These observations, obviously limited to well known pests, are presented for the purpose of emphasizing the danger that attends the introduction of some foreign insect. Only brief experience is needed to appreciate the difficulty of securing accurate data, especially on species

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[14]Jour. Econ. Ent. III, p. 157, 1910.

[15]A. Kolumbacsi legy, Dr. Horvath Geza, in Rovartani Lapok, Vol. 1, No. 10, Budapest, 1884.

of supposed lesser importance. Far too little is known of the actual history of many of these likely to be introduced to warrant us in ignoring or risking their establishment.

PRESIDENT ARTHUR GIBSON: We will now listen to a paper by A. W. Morrill.

OBSERVATIONS ON A NEW AND IMPORTANT COTTON PEST

By A. W. MORRILL, *Los Angeles, California*

(Withdrawn for publication in a later issue.)

PRESIDENT ARTHUR GIBSON: The next paper is by S. M. Dohanian.

SOME OF THE IMPORTANT FOREST INSECTS OF WESTERN EUROPE

By S. M. DOHANIAN, *U. S. Bureau of Entomology, Melrose Highlands, Mass.*

ABSTRACT

Several insects attacking the oaks and pines in the forests of western Europe are mentioned, together with their life histories and methods of control.

INTRODUCTION

During the greater part of the past three years the writer has been engaged in entomological activities in western Europe. In 1924 and again in 1925 he was detailed by Mr. A. F. Burgess, of the U. S. Bureau of Entomology, for work there in connection with the study and importation into the United States of the natural enemies of the gipsy moth and the brown-tail moth. Late in 1925 and early this year he investigated, for an American commercial concern, methods of artificial control for some of the most serious pests of grape vines, greenhouse insects, and certain subterranean insects and rodents. Incidental to, and in connection with, these various studies he has accumulated notes on some of the important insect problems, not only through personal studies and observations, but also by means of conferences and consultations with entomologists in the several western European countries he has visited. These countries are Spain, Portugal, France, Switzerland, Italy, Germany, England, Austria, and Holland.

We learn from history, as well as from entomological tradition, that even during the period of the American Revolution, when travel was slow, injurious insects were transported long distances and introduced into new areas thousands of miles from their native homes. Since

those days scores of insects have been transported, accidentally or otherwise, from their native habitat, and having become established in their new environment caused enormous economic losses. This danger becomes increasingly imminent with the rapid development of the swifter methods of transportation and desire for travel characteristic of our era. This paper is presented in the hope that the biological information it contains may be found useful in combating any of the species discussed in the event of its trespass into American territory. Usually considerable time is lost in the preliminary studies of its life history and habits, during which a new invader gains much headway, not only in increasing its numbers but also in the area infested.

The Forests of Western Europe

No official figures were given me of the areas under forest canopy for any of the countries except in the Iberian Peninsula. In Spain and Portugal approximately 49 per cent of the land is devoted exclusively to forest growth. In both of these countries the dominant species are oaks and pines, which comprise some 80 per cent of the total growth. Among the other species of economic importance may be mentioned chestnut, ash, elm, poplar, maples, willow, etc. In these two countries and in Italy the predominating oak species are, in the order of their importance, *Quercus ilex*, cultivated for its prolific acorns for hog food, *Q. suber* (the cork oak), *Q. sessiliflora*, *Q. robor*, *Q. lusitanica*, *Q. pedunculata* and *Q. toza*. The six important pines are *Pinus sylvestris*, *P. pinea*, *P. halepensis*, *P. austriaca*, *P. pinaster* and *P. strobus*.

It is not intended even to mention here all of the important insect pests of western Europe, but to discuss in detail a very few of the most serious and persistent enemies of the forests with which the economic entomologists of Europe must contend.

The Oak Pests

The gipsy moth (*Porthetria dispar* L.), a pest of the first order over all Europe (except probably the Scandinavian countries), is sometimes controlled by its numerous natural enemies, but periodically makes its appearance as a serious devastator. The brown-tail moth (*Nygmia phaeorrhoea* Don.) attacks both forest and fruit trees. Its behavior in Europe closely resembles that in America, where it is now assuming the rôle of a native insect. It is interesting to note that in Spain, where it is more common in the forests than on fruit trees, it will not feed on the evergreen oaks, but confines its damage to the deciduous oaks and to elms. In Italy it is a pest of both forest and fruit trees, being found

at times in abundance even on the "horse chestnut," *Aesculus hippocastanum*. In mid-December, 1925, while traveling from the Rhine Valley in Germany to Switzerland, the writer saw webs of the brown-tail moth on fruit trees along the line of the railroad, perhaps more abundantly than he has seen them at any other time either in America or in Europe. For a distance of between 25 and 30 miles there did not seem to be a single tree unmolested by this pest. A majority of them harbored hundreds of webs. The admirable "clean-up job" done here is worthy of emulation, for on March 21, 1926, when the identical journey was being repeated, not *one* web could be seen on the trees. Where thousands upon thousands of webs existed three months before, not even one could be seen now. Every one of those webs had been cut and undoubtedly burnt.

Both the brown-tail moth and the gipsy moth, but particularly the latter, appear to favor chestnuts more in Europe than they do in America. In the summer of 1924 the gipsy moth completely defoliated a chestnut grove of several hundred acres in Tessin, in southeastern Switzerland. Dr. F. Stellwaag, of Neustadt, Germany, lists 34 parasites as enemies of the brown-tail moth, and the same number of parasites which aid in keeping the gipsy moth in check in Europe.[1]

Another general pest very common in all of western Europe is *Bombyx neustria* L. Evidently this insect is found generally throughout Europe, for Mr. R. T. Webber, of the Bureau of Entomology, while scouting for parasites of the gipsy moth and the brown-tail moth during the year 1924, reports it rather abundant in eastern Europe (Roumania) and also in central Europe (Czechoslovakia). This species also is not fastidious in its choice of food plants, but attacks forest and fruit trees equally well. Among the former may be mentioned oaks (of which the deciduous varieties are preferred), poplars, beech, hornbeam, while the apple, pear, apricot, cherry and mulberry are the fruit trees on which it is most abundant. The production of fruits is seriously handicapped by the feeding of the larvae on the foliage. Its biology is similar to that of the American tent caterpillar of this country, to which species it is closely related. The female moth deposits her complement of eggs, 200 to 300, cementing them on small twigs in the form of a ring not unlike those of our American species. These overwintering eggs hatch from about the middle of April to early in May. The larvae become full grown after feeding about two months, the single annual generation being completed by the appearance of the adults in July.

[1]Stellwaag, Dr. F. "Die Schmarotzerwespen als Parasiten." Monog. zur angewandten Entom., No. 6, pp. 88–91, Berlin, 1921.

There are recorded five larval parasites, and five which attack its eggs. The artificial methods of control recommended by Europea entomologists are to collect and burn the egg masses, and to spray the foliage of infested trees with arsenicals. Some success has been achieved by the latter method in Spain, where the spraying was done in combination with that for *Tortrix viridana* and *Porthetria dispar*.

Among the enemies of deciduous forest trees, and one that confines its activities solely to forest growth, perhaps there is none that causes more damage than a Tortricid which is found almost everywhere in Europe. The writer is familiar with its ravages in western Europe, while Mr. S. S. Crossman, of the Bureau of Entomology, has reported it as abundant in some of the central European and the Balkan countries during his research travels in these countries in 1923 and 1924, in connection with the gipsy moth and brown-tail moth projects. It would be exceedingly difficult to estimate the annual loss caused by *Tortrix viridana* L. It is a most voracious feeder on the flowers and foliage of the oaks. It has but a single generation a year. The time of hatching of the overwintering eggs and the length of the larval period vary greatly. Normally it is said to hatch in Portugal late in February and early in March; in Spain, late in March and early in April; in Italy, about the middle of April, and in France, about the first of May. The length of the larval period—the stage in which it does its mischief— also varies considerably in different parts of Europe. In Spain and Italy larvae may be found in the field for only about 4 weeks, while in Portugal and England they feed continuously for about 10 weeks. The pupal stage is about 10 days, and two or three days after the adults have emerged mating takes place and the females begin depositing their eggs. The eggs are laid singly or in groups of twos or threes, but not in masses, as is the case with the gipsy moth and the tent caterpillars. Each egg has an outer envelope, bearing scales from the abdomen of the female moth. The female selects locations very near the buds to deposit her eggs; and almost invariably on the current season's growth or on the growth of the previous year, for, directly upon hatching, the young larvae go there to feed on the bursting buds and flowers. In 1924 an attempt was made in Portugal to control this insect by taking advantage of this habit of depositing its eggs only on the growth of the current season and on that of the season previous. The federal agricultural school authorities in the Province of Beja, in southern Portugal, believed that if all such growths on *Quercus ilex*, the favored food plant of this pest, was cut off early in the winter and the trash burnt, all the eggs in the

area would be destroyed and the pest would be exterminated. Accordingly a large plot of 46 hectares (approximately 100 acres) was selected in the heart of the 300 hectare forest owned by the school, and all of the growth of 1923 and 1924 was carefully cut and burnt. When the writer saw this experimental plot in the spring of 1925 it was a sorry looking sight, without a green leaf in evidence, in sharp contrast to the surrounding evergreen oaks. That this plot will not be defoliated by *Tortrix viridana* for 3 or 4 years seems assured, but the fact that both the male and female moths are capable fliers appears to have been overlooked when this experiment was planned. It is a matter of time only, probably 4 or 5 years, before the pest becomes just as abundant here as it ever was before this unique treatment.

On valuable woodlands this pest is controlled artificially by spraying with arsenicals. And this can be done quite economically, for *Q. ilex* seldom grows to a height of more than 30 or 35 feet and the trees are cultivated far apart. Furthermore, spraying for *T. viridana* can be timed also to take care of the early stages of the gipsy moth and of *B. neustria*. Usually one of these pests is found in combination with one or both of the other two.

Over Europe generally *Tortrix viridana* has a formidable array of natural enemies. There are more than 40 parasites of the larvae and pupae,[2] exclusive of predators and the egg parasites. It seems reasonably certain that there are some parasites of the eggs, although so far as I know to date none have been found. Probably the difficulty of locating the small, inconspicuous, and isolated eggs is chiefly responsible for the lack of knowledge concerning its parasites. Despite the large number of natural control agencies *Tortrix viridana* has been abundant in the central and southern countries of Europe over a long period of time.

The Pine Pests

Several important Scolytidae and Aphiidae attack the pines of western Europe, but the principal enemies are *Thaumetopoea* (*Cnethocampa*) *pityocampa* Schiff., and the Tenthredinid *Lophyrus* (*Diprion*) *pini* L.

The first of these is commonly known as the "Procession Moth" and can be found in practically all pine stands of southern Europe and France. This insect has a single generation a year. The female deposits its eggs about the middle of July, these hatching about four weeks later. The gregarious young larvae then form a common web to which they

[2]Seabra, A. F. de, et Dos Santos Hall, F. A. "Contributions pour l'Histoire Naturelle des 'Tortrix' der Chêne-vert a l'Alentejo." Mem. et Études du Mus. Zool. de l'Univ. de Coimbra, Portugal, 1925. Ser. II. No. 1, pp. 11–45.

return after feeding. Feeding continues until late autumn, when, just before going into hibernation, the web is greatly strengthened. This web is composed of a series of connected tunnels, with a rather large opening for communication with the exterior. The average size of these webs is larger than that of the American tent caterpillar so common in New England. The larvae recommence feeding with the very first days of spring, becoming increasingly ravenous as the time for pupation approaches. About the middle of May the full grown larvae abandon their companions and common home, and migrate to the soil beneath, where they pupate from 3 to 4 inches below the surface. The adults emerge late in June or early in July. The procession moth receives its name from the habit of the larvae of searching for food in regular columns or files. One larva will lead "the procession," the head of the second larva touching the posterior segment of the leader, and the head of the third touching the last segment of the second, and so on down to the last larva. An inquisitive French entomologist, desirous of learning just how long they would "follow the leader," regulated the march of the leader of a certain procession so that it finally had its head touching the posterior segment of the last one in the march, the entire colony thus forming a complete ring. He discovered that this particular procession continued for 72 hours before one of the number finally decided to break away in an independent search for food, and the others followed meekly.

Although none of the many species of pines are free of the attacks of this pest, there appears to be a decided preference for *P. sylvestris*, *P. pinaster* and *P. halepensis*. The defoliations caused by the larvae of the procession moth weaken the trees, rendering them subject to the attacks of other insects, but specially of certain Scolytidae. Because it has but a single generation a year this insect is said to be incapable of killing pines. But pine stands are unable to survive the combined attacks of the procession moth and the borers. For the control of the moth the following treatments are recommended: (1) cutting and burning the webs; (2) collecting and killing the larvae; (3) spraying with lead arsenate, and (4) pumping kerosene into the webs by a small hand injector.

The most obnoxious hymenoptera in Europe are members of the tenthredinid genus Diprion (Lophyrus), of which *pini* L. and *pallidus* Klug are the worst offenders. The former, *D. pini*, is said to be abundant generally throughout Europe wherever pines are to be found. Although it is reported to favor isolated pines, or those in very open-

grown stands, it will attack as readily pines in thick groves. It is exclusively an enemy of pines. In Italy its cycle of destructive invasions is said to be about twelve years. The female, upon emergence early in April, inserts her eggs singly in lacerations which she makes for the purpose in the needles of the preceding season. In two or three weeks the eggs hatch and the young larvae at once commence to feed on the more tender needles. If, however, these are not sufficient they will also attack and completely devour the two-year-old needles. After about two months' feeding a strong cocoon is spun by the mature larva in which to pupate. These cocoons are attached to the rough bark of the trunk or branches. In two or three weeks after pupation the second generation adults emerge. Prof. Giacomo Cecconi, of Fano, Italy, states that the full grown larvae of the second generation migrate into the soil to form their cocoons in which the larvae hibernate; pupation occurring in the cocoons soon after the beginning of March.

The method of control recommended is the collection and destruction, by hand, of the larvae and cocoons; spraying the pines with a 1 per cent solution of lead arsenate is said to be effective in killing the very young larvae. *D. pini* is said to be subject to attack by a great many parasites. Birds also aid in keeping its numbers down.

The writer secured fragmentary notes on some other forest insects of western Europe and fuller notes on several others injurious to agriculture in general. These have been omitted above, but it is hoped that they will be eventually recorded in American literature. As has been previously stated, these notes and observations were made while engaged on studies of the parasites and predators of the gipsy moth and the brown-tail moth, without any loss of time and at no additional cost than that incurred in the proper execution of that project. This illustrates one of the attendant benefits derived from necessary foreign work in entomology.

PRESIDENT ARTHUR GIBSON: Mr. T. E. Snyder will read the next paper.

TERMITES MODIFY BUILDING CODES

By THOMAS E. SNYDER, *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

Forty-two species of termites are widely distributed throughout the United States and, due to the fact that the untreated woodwork of buildings is often directly in contact with the ground, termite damage to buildings throughout Eastern United States, the Gulf States, Southwest, Central West and Pacific Coast is serious. The

only effective permanent preventive and remedy is the proper construction of buildings. Insulation of all untreated woodwork from contact with the ground and termite shields will protect against subterranean termites, whereas against the nonsubterranean termites the interior woodwork and furniture must be impregnated with chemical preservatives. In Honolulu, Hawaii, a million dollars is the annual damage to buildings done by termites. This city has recently adopted a building code containing 14 points relating to termite control; 80% of the frame buildings in New Orleans have been damaged by termites and 50% of the business buildings at Pasadena, Calif., some dangerously. Slightly modified building codes for the entire west coast, from Seattle to San Diego, are being considered. The aim of the Bureau of Entomology is standardized, uniform, modified building codes for all the regions where termite damage is serious.

Owing to lack of information on the destructiveness of our forty-two species of termites or white ants, and their wide distribution throughout the United States, buildings are often erected with untreated woodwork directly in contact with the ground, leaving the way open for the entrance of subterranean termites.

In consequence of such improper construction, termites burrow into the wood and may greatly damage the woodwork of the building before their presence is detected. It is a great hardship for a man on a moderate salary to make a large initial outlay on a new house and, after one or two years, be forced to expend several hundred dollars additional to reconstruct the building to eliminate termites. The cost of repairing termite damage to buildings and preventing further attack averages from $500 to $2000, but in some cases is as high as $10,000 to $25,000.

Termites in the United States

Despite popular opinion, practically all the termite damage in the United States is done by native species and such serious damage occurs throughout eastern United States, the Gulf States, Southwest, the Central West and the Pacific Coast. Damage by termites in the "corn belt" is almost as serious as in some of the Southern States. Such damage by termites occurs not only in cities but also in rural regions.

Termites of two distinct types occur in this country. Those subterranean in habit burrow through the soil and only attack wood indirectly from the earth, with which they must maintain contact, to obtain the moisture so necessary to their life. (Pl. 8) Subterranean termites are widely distributed throughout the United States, over most of which they damage buildings.

Nonsubterranean termites never burrow in the earth, but attack wood directly; they do not require much moisture and will survive in wood containing less than the 10% moisture content normal to air dried wood; small pellets of digested wood betray their presence. These

"powder-post" termites are not widely distributed and damage to buildings only occurs in that half-moon of country, lying between a slack line from Norfolk, Va., to San Francisco, Calif.

Insulation Against Subterranean Termites

The only effective permanent preventive and remedy is the proper construction of the building with the knowledge of the habits of termites and the specific that will eliminate them. This specific against subterranean termites is "insulation" of all untreated woodwork from contact with the ground; it can be accomplished by the use of stone, concrete or brick foundations and lower flooring or the use of foundation timbers impregnated with coal-tar cresosote and metal termite shields. The greatest portion of all termites which damage buildings in the United States are of subterranean habit; if they can be kept from reaching woodwork from the ground they cannot survive in the building. Also, if present in a building, after all untreated wood, such as joints, wooden floors, sills, etc., has been removed from contact with the ground, they will die out, i. e., dry up; even if the termites have penetrated to the height of several stories in the building. They have been cut off from their moisture supply in the ground which is necessary for their life.

Impregnation of Woodwork against Nonsubterranean Termites

Where termites that attack wood directly and not from the ground occur, as well as subterranean termites, it is suggested that only woodwork impregnated with preservatives be used for exterior and interior construction, unless it is impracticable to obtain such treated wood.

While impregnation with coal-tar creosote is the most effective treatment for foundation timbers to be set in contact with the ground, for interior woodwork and furniture, and the like, not in contact with the ground, impregnation with zinc chloride or other standard preservatives, is recommended; wood so treated can be finished and painted.

Building Code Modification

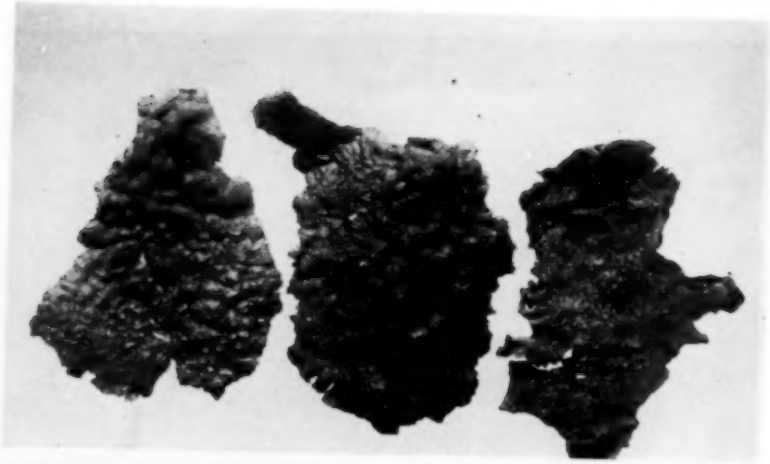
In 1923 the first attempt was made to have building codes modified to prevent termite damage and this was made in Burlington, Iowa, where efforts were made to have no untreated wood placed in contact with the ground but that all such timber should be treated with coal-tar creosote.

Recently the Bureau of Entomology of the Department of Agriculture has been widely advocating the slight modification of the building regulations of various cities so as to include simple rules to prevent attack by these insects. This educational propaganda addressed to city

Temporary government building at Washington, D. C., the untreated wooden foundations of which were weakened by subterranean termites (Reticulitermes). $140,000 were spent in repairing temporary wooden government buildings at Washington, D. C., in 1926, that could have been saved by using concrete foundations or timber impregnated with coal tar creosote.

All wood, model termite-proof building erected on Barro Colorado Island, C. Z., Panama, to demonstrate that timber grown in the United States, properly impregnated with preservatives will prevent termite attack.

Tests at Falls Church, Va., of mortars and concretes for brick foundations on or below the surface of the ground; suitable mortars and concretes will prevent both mechanical and chemical action by subterranean termites.



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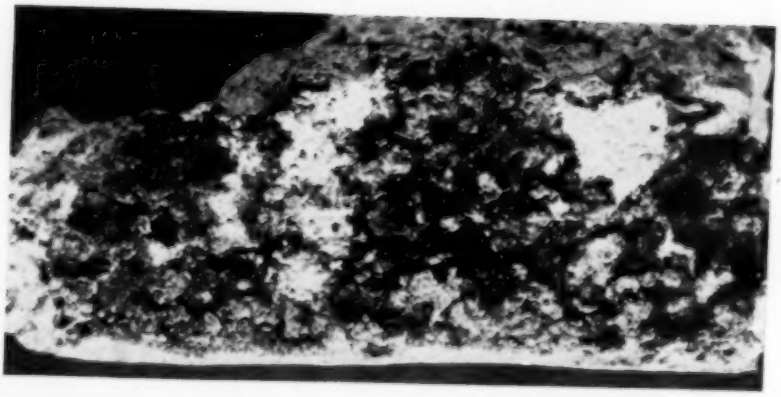

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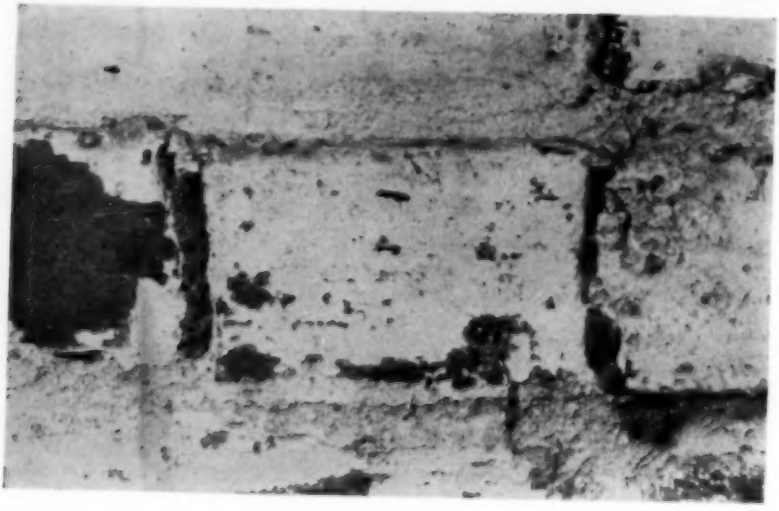

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See page 319 for explanation of figures.

engineers has been conducted with the assistance of the National Lumber Manufacturers' Association, the United States Department of Commerce, Lumber Division of the Bureau of Foreign and Domestic Commerce, the American Wood Preservers' Association and the Associated Press. The National Wood Utilization Commission appointed by President Coolidge, with Secretary Hoover as chairman, has an ant-proofing campaign on its program, which will receive early action.

Termite-proofing buildings campaigns have been advised in certain cities similar to that conducted by the Public Health Service in rat-proofing. Indeed rat-proofing, fire stops and the prevention of decay and insect damage can all be effected by similar methods.

In rural regions where there are no building codes or chambers of commerce, the educational work can be conducted by prominent citizens with the help of county agricultural agents.

In Honolulu, Hawaii, a million dollars is the annual damage to buildings done by termites; this city has recently adopted a building code containing 14 points relating to termite control; 80% of the frame buildings in New Orleans have been damaged by termites and 50% of the business buildings at Pasadena, Calif., some dangerously. Slightly modified building codes for the entire west coast, from Seattle to San Diego, are being considered. Similar serious damage occurs in southern Florida and in the southwestern states. The aim of the Bureau of Entomology is standardized modified building codes for all the regions where termite damage is serious. The Pacific Coast Building Officials' Conference of Long Beach, Calif., is already in consultation with the Bureau of Entomology.

Hits Small Householder

While special effort has been made to protect the small householder from speculative and careless builders many of the more permanent modern buildings are improperly constructed. This applies to some of the government buildings in Washington. With the cooperation of the Superintendent of Public Buildings and Grounds much progress has

1.—Builders are finding that while tar and tar paper are used in water-proofing wood used in floring, these substances will *not* prevent attack by our native subterranean termites or "white ants". These insects penetrate such moisture-proofing materials and carry to the wood the moisture necessary for their life. Insulation of wood from the ground by the use of concrete or by impregnating wood with coal-tar creosote is necessary to protect it from these subterranean termites.

2.—Inferior grade of mortar penetrated by subterranean termites in brick foundations of buildings in Maryland.

3.—Inferior grade of concrete penetrated by subterranean termites in locks, Panama Canal.

been made in repairing such buildings and some such work has been done with temporary buildings where practicable.

The use of untreated wood in the foundation of buildings is a great waste of wood and the replacement cost is often very much greater. A model demonstration, termite-proof building has been erected in Canal Zone, Panama (Pl. 9) by the American Wood Preservers' Association and associated companies in consultation with the Bureau of Entomology to serve as an object lesson; other similar buildings are to be erected in the United Statees.

The Modified Code

No foundation timbers, floors, sills, clapboards, etc., of untreated wood should be laid on or in the earth, and untreated beams must not be laid in concrete without at least one inch of concrete underneath and separating it from the earth. A special grade of hard mortar (Pl. 10 and 11, figs. 2, 3) should be used in making cement for foundations or in cellar walls where they are in contact with the earth, since termites are able to penetrate certain kinds of mortar after some years' service. For greater safety all brick work extending below the surface of the ground should be faced and capped with concrete at least one inch thick. Metal termite guards should be provided between the earth and treated foundation timbers, stone, brick or concrete foundations. Termites construct over impenetrable substances earth-like shelter tubes of small diameter through which they travel to reach untreated wood. In consequence they can be kept out of buildings by means of metal barriers. By simply inserting a sheet of galvanized iron, zinc or copper or "termite shield" into the masonry and turning the projecting edges downward at an angle, communication of termites with the earth, where they obtain moisture, can be cut off. In less pretentious frame buildings, metal caps are placed over the tops of construction stone piling or pillars, or wooden supports. Tar is no protection for wood. (Pl. 11, fig. 1).

This is a similar method to that used in rat-proofing corn cribs. It is effective and practicable where untreated timber is placed over masonry foundations. These shields need not be unsightly but can be made decorative or ornamental.

These slight modifications of the building regulations of cities by city engineers would save much property as well as the time and worry to householders. It is a form of house insurance. A prospective home builder should insist on obtaining this safeguard! It will pay in the end!

There are three principal points—insulation of untreated woodwork

from the earth, metal termite shields to shut off the shelter tubes and treatment of interior woodwork and furniture with preservatives; the latter recommendation is essential only in the Gulf States, Southwest and southern California.

MR. E. V. WALTER: I would like to ask if there are any kinds of wood that are not bothered.

MR. T. E. SNYDER: There are some woods which are very resistant to termites. Redwood is one, provided it is not in contact with the ground. Redwood has been used very successfully in the Philippines and Central America. We know of no species of wood anywhere in the world that is immune to attack.

MR. E. V. WALTER: How is cedar?

MR. T. E. SNYDER: The heartwood of cedar is very resistant.

PRESIDENT ARTHUR GIBSON: The next paper is by A. G. Ruggles.

THE GREEN BUG IN MINNESOTA[1]

By A. G. RUGGLES and F. M. WADLEY

ABSTRACT

The green bug, *Toxoptera graminum* Rond., destroyed about 15 million bushels of oats in Minnesota in 1926. The cool, dry June was very favorable for the development of aphids.

Certain facts so far discovered in the biology of the insect make it appear that the insect did not overwinter in Minnesota but was blown in by the wind. The weather records show that strong winds at favorable dates might be responsible for such an infestation.

In 1926, Minnesota, for the first time in its history, was the center of a green bug infestation. It seems to have been the only outbreak of importance in the entire country during the year. The first report (concerning the green bug injury) came to the office about June the 10th. Previous to this time, the farmers had attributed the injury to the dry weather or to the frost. When the grain did not improve after ample rains early in June, a few progressive farmers examined their fields and found plant lice present. They immediately got in touch with experts at the Experiment Station. Dr. C. E. Mickel visited the scene of the outbreak and pronounded it the work of the green bug. Dr. Mickel kept closely in touch with the injury during the entire season and both he and the junior writer traveled over the state, noting the spread of the insect. On June 10th, the outbreak was in an advanced stage in a

[1]Published with the approval of the director as paper No. 662 of the Journal series of the Minnesota Agricultural Experiment Station.

definite area covering parts of Kandiyohi, Stearns and Meeker counties. There seemed to be no focal point for the infestation. The numbers of aphids were equally distributed over the whole area. By the third week in June, adjoining counties were showing injury and the aphids were beginning to be found widely over the state.

Injury in the first area increased very fast during the second week of June. In general, the infestation followed this same course in its development in each locality. The food plants began to die, winged forms developed and migrated, those remaining wingless died for lack of food or fell victim to enemies and the numbers fell off very suddenly. The map shows approximate dates of maximum numbers in each locality. It will be noted that this gives roughly a concentric arrangement. The inner circle represents the area of primary infestation, while infestations outside this area are thought to be secondary and to have originated from the first by means of migrating forms. Early oats were attacked in the primary area, while late oats were attacked over the rest of the state. Had the aphids developed simultaneously in all parts of the state, it does not seem possible that early and late oats would have been attacked in this manner. At the northeast experiment station at Duluth, late oats sowed June 4th were attacked before June 20th. The migrants evidently were coming in here about June 15th. Flying swarms characteristic of green bug outbreaks, were observed by different members of the staff. Depending upon the prevailing winds, they flew southeast, west and north.

In August green bugs had become very scarce all over the state, but a few could be found in volunteer grain around elevators and mills nearly everywhere. In September they seemed to increase slightly and some migrants developed. In October decreases occurred and they disappeared altogether from a number of localities.

Injury

Oats were severely injured, wheat much less, and barley and rye were not perceptibly injured even in the region of the most severe damage.

In the original infested area in west central Minnesota, damage was very heavy. Some field were plowed up and planted to catch crops or abandoned; others yielded poorly with spots entirely destroyed. Many fields in counties adjacent to this area were more or less severely injured. In southern and eastern Minnesota in general, only very late fields were strikingly injured, but all oat fields contained some green bugs, and many must have been slightly reduced in yield. In northern Minnesota late fields were considerably injured. In the Red River valley, an im-

portant grain area, green bugs became abundant and somewhat injurious in places. Though the drought of early spring and summer was quite general, many fine oat fields were seen in sections not severely affected by green bugs.

In the state as a whole, the oat crop estimate of December 1 was about 130 million bushels. If the acre yield had come up to the average of the five preceding years, the crop would have been about 165 million bushels. Barley is a crop governed by the same conditions as oats and raised all over the state. The barley acre yield declined 7 per cent from the 5-year average which can properly be accounted for by drought. Eleven million bushels of the decline in the oat crop can therefore be attributed to drought. But the actual decline was 35 million bushels. Unpublished figures from the U. S. Bureau of Crop Estimates, secured from the Division of Farm Management at Minnesota, covering conditions from 1919 to 1923, indicate a high degree of correlation in the oat and barley yields in the state. In both dry and moderate years, estimated drought damage to oats and barley was always nearly the same. Hence drought cannot account for any drop in the oat yields over 11 million bushels. Some factor not affecting barley is responsible for about 24 million bushels reduction in the oat crop, and excepting the oat rust the green bug is the only important one we know. We believe 15 million bushels of oats a conservative estimate of green bug loss in Minnesota in 1926.

Biological Notes

The green bug matures in about 8 days at 70°F. and 12 days at 60°. It will not develop at all below about 45°. Minnesota summer temperatures seldom rise high enough to interfere with its activities, even temporarily. It may reproduce from two weeks to nearly a month, at an average rate of 3 or 4 young per day with a maximum of 8. Apterous parents on oats have produced 51 to 83 young, averaging 68; winged females, few, up to 50. Aphids on wheat produce fewer young than on oats, the preferred food plant. Fewer young were produced after the sexes began to appear.

The sexes were not produced outdoors this fall, either in the field or in outdoor cages. In the outdoor cage, one oviparous female was seen early in November, just before permanent freezing weather set in, but too late to produce eggs. In the greenhouse the males, females and eggs were produced in some numbers. It appeared that Minnesota temperatures are too low for much development after the factor producing the sexes begins to operate in October. This accords in general with Vickery's and Webster's results in 1907 (Minn. Bul. 108). The other

two species of common grain aphids, *Macrosiphum* and *Rhopalosiphum*, produced the sexes outdoors in October. All but a few green bugs survived a temperature of 24°F.; nearly all died at 8°; the remainder perished when a cold spell carried the temperatures down to about 0°F.

Besides oats and wheat, the green bug will multiply to some extent on bluegrass and orchard grass. It increases on wild oats. On other grains, and annual and perennial grasses occurring commonly in Minnesota, we have not been able to colonize it permanently, though it may feed and stay a few days. On all plants on which any amount of feeding is done, red spots appear due to killing of leaf tissue. This factor and the green bug's habit of concentrating their attack until the plant is killed, and then migrating in a body, give the species its highly injurious character. The numbers of aphids will reach from 2000 to 4000 per square foot before oats go down from their attack.

The ladybird beetles were most important as aphid enemies during the outbreak. *Coccinella 9-notata* Hbst., *C. transversogutta* Fald., *Hippodamia convergens* Guer., *H. 13-punctata* Linn. and *H. parenthesis* Say were the only ones to become numerous. They reached great numbers owing to the abundance of food, a brood maturing late in July. From 3 to 18 per square yard occurred in infested fields. Adults will consume 25 to 50 aphids a day. Syrphids were next in importance and in earliness of appearance. Hymenopterous parasites were present, but did not become numerous and were late in appearance; Chrysopids scarcely appeared before the outbreak was over. A Cecidomyid species destroyed aphids in the greenhouse.

The Origin

The origin of this unprecedented northern outbreak is a highly interesting question. Though most early and severe in Minnesota, it extends, according to information given by entomologists and reports from the Crop Pest Survey, from North Dakota to Ohio and from Iowa to Manitoba. Mr. Nelson, an elevator manager in the original infested area, reported and described unmistakably an outbreak near Jamestown, North Dakota, late in June. In Wisconsin, infestation reported in the western part can be logically related to the Minnesota spread. This is also true in South Dakota. A center in northeast Wisconsin and adjacent upper Michigan, and another in southeast Wisconsin, cannot be so related. In Iowa two small centers were reported, one in central and one in western Iowa. There were also reports from Ohio and Indiana. In south central Kansas, the junior writer observed green bugs appearing late in April and increasing to a small extent in May.

Professor Dean reported a very light infestation in Kansas. Professor Sanborn spoke of the green bug wintering successfully, and increasing in early spring in north central Oklahoma. No reports have been received from Nebraska.

Fig. 12.—*Toxoptera graminum*, approximate dates of maximum infestation, Minnesota, 1926. Roman numerals indicate the week, Arabic numerals the month; *e. g.*, 6–IV indicates the 4th week in June.

In looking for unusual weather associated with the outbreak, we find a rather mild winter, a very windy and dry spring and a dry and cool early summer. The mild winter is of obvious importance if we assume the species hibernated here. The windy spring is equally important

if we assume it migrated from the usual hibernating regions. In looking over weather bureau daily maps, from April 15 to May 15, we find two periods, April 19–20 and May 4, 5 and 6, during which the wind blew strongly and uniformly straight north from known infested territories; and one April 29–30 on which it blew northeast. On looking over similar records for 8 years back no other such windy spring was found. At different stations in the path of the wind the total wind movement during each period was from 500 to 1800 miles. The history of the green bug in other places shows that it reaches its greatest numbers in regions which are dry during the height of its greatest reproduction period. The normal rainy Minnesota June evidently offers a severe handicap. The cool June of 1926 may also have restricted the activities of aphid enemies.

Any theory concerning the origin of the infestation must explain especially the distribution of the aphids and their early development in west central Minnesota. Grain is not up there until about April 20th, and there could not have been more than five generations after this to the peak of the outbreak. Hence, the aphids must have arrived early, of if they came later, arrived in large numbers. The aphids could hardly have wintered alive, as a temperature near 0°F. kills all of them. Even if some were sheltered under snow where temperatures remain above this mark, it seems impossible that they should live five or six months under such conditions. However, this possibility is being investigated. The two theories given most attention are that they wintered in the north, as eggs, and were favored by a dry season and that they migrated in on the wind from Oklahoma where we know they wintered. The periods of south wind could account for the western Iowa, western Minnesota and North Dakota centers, and the southwest wind spell for central Iowa, eastern Wisconsin and upper Michigan centers.

The points in favor of the two theories of origin may be summarized as follows:

OVERWINTERING IN MINNESOTA

1. The species has been shown to winter as eggs in Indiana (U. S. Bu. Ent. Bul. 110) and could probably withstand a mild winter in Minnesota.
2. A few *Toxoptera* were taken in 1925 at St. Paul.
3. The eggs may have overwintered in favorable localities and migrated locally.
4. A flight of 800 miles for this insect seems almost impossible.

MIGRATION

1. The sexes were not produced outdoors in 1907 and 1926 in Minnesota and the fall of 1925 was much less favorable than those two years, due to near-zero weather late in October.

2. Should eggs be deposited they would probably hatch late in April in this latitude. The stem-mother (recorded as wingless) would have to mature and produce young, which would also have to mature, before migrants could invade the fields.

3. The first infestation was not in the mildest part of the state, but in a territory of more severe winters and high spring winds.

4. Winds having the right date, direction and velocity to explain infestations occurred.

5. The possibility of the insect traveling so far does not appear altogether incredible. We have many records of frail insects being wind-borne, including observations on the green bug itself in U. S. Bu. Ent. Bul. 110, and the species can live several days without food at temperatures around 50°F.

From the present data it appears that the migration theory is more probable, yet we are far from being entirely satisfied with it. Further investigations on the ecology of this insect are being carried on.

PRESIDENT ARTHUR GIBSON: Next is a paper by F. A. Fenton.

WINTER SURVIVAL OF THE COTTON BOLL WEEVIL AT FLORENCE, S. C.

By F. A. FENTON and E. W. DUNNAM, *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

From 1922 to 1926, an average of 3.27 per cent of cotton boll weevils survived the winter in various types of protective shelters at Florence, South Carolina. Practically all weevils issuing from hibernation before cotton was available as a food plant died, the average longevity at this time being 5.64 days. Of weevils emerging from winter quarters after cotton came up, and placed in field cages on young cotton plants, a great majority died before these started to square, their average longevity under these conditions being 8.12 days. Weevils emerging at or after the time when squares were developed on cotton plants were longer lived in these same field cages than those emerging prior to this time, the average longevity for males being 16.28 and for females, 13.42 days. The maximum longevity at this time was 66 days for males and 46 for females. According to trap crop records and field counts, weevils continued to enter the cotton fields for three to four weeks after the first squares formed, or until about the time the first blooms appeared. In 1925, 90.01 per cent of the surviving

weevils had emerged in all cages at the time cotton began to square, 73.04 in those in the woods, 90.37 in those in the field, and 47.01 per cent in the trap crops. That year emergence in the hibernation cages located in the woods corresponded very closely with that in the two trap crops after May 14. In 1926, 98.03 per cent of the weevils had emerged in all the hibernation cages when cotton began to square, all in those in the woods, 97.91 per cent in those in the field, and none had been collected in the trap crops. The emergence of the weevils in the hibernation cages is called the "total emergence," and that in the trap crops the "effective emergence," since the latter represents those weevils that emerge late enough to find cotton. Trap-crop records and field counts for the two years indicate that there may be a considerable migration of weevils to cotton fields after first square production, although this may actually represent a small percentage of the total survival for that year. The use of the trap crop in determining the rate of "effective emergence" of the weevil from hibernation is more reliable and more representative of field conditions than is that of the hibernation cage.

One of the most remarkable things about the life history of the cotton boll weevil is the fact that, although native to tropical America, it is able to pass the winter successfully in the northern edge of the cotton belt, hundreds of miles north of its original habitat and under radically different climatic conditions. This paper presents data that show how this species survived the winters at Florence, South Carolina, from 1922–23 to 1925–26. The writers have made most of the observations but have also used some hibernation data obtained prior to their arrival at Florence in the spring of 1924. Records before this time were made by R. W. Moreland. All experiments have been under the direction of B. R. Coad, in charge of cotton insect investigations, U. S. Bureau of Entomology, Tallulah, Louisiana.

Method of Procedure

Weevils were collected from cotton fields in the fall and placed in lantern globe cages and battery jars where they were fed on cotton squares until needed. At the end of each week, or at the date it was decided to install these in hibernation, they were counted and released in the cages. The latter were of the standard type specified by the Delta Laboratory at Tallulah, Louisiana, being four feet in all three dimensions with rust-proof screen wire. There were usually four series of cages for use in determining various points about weevil hibernation, as follows: One consisted of weevils released in pine straw at weekly intervals from early September until the first killing frost, to find out the effect of date of installation on percentage of survival. In the second series, weevils were released in cages with various types of debris, to determine the effect of shelter on survival. In this series the following materials were used: cotton stalks alone, or in combination with pine

straw, pine straw alone, cornstalks, Spanish moss, oat straw, sawdust, or with no other protection than the cage itself. In the third series different numbers of weevils—25, 50, 75, etc., up to 500 to a cage—were released to determine the effect of numbers on survival. The fourth series had cages installed at weekly intervals in the field and also in the woods to determine the effect of out-door environment on survival. Each cage was examined daily from March to July 15 and the number of weevils which issued recorded.

Per Cent of Survival

In 1923, 442 weevils survived out of a total of 4,000 placed in hibernation cages during the fall of 1922, or there was an average survival of 11.05 per cent. The survival in other years was as follows: 1924, 75 out of 21,617, or 0.34 per cent; 1925, 1,262 out of 19,427, or 6.49 per cent; 1926, 102 out of 12,425, or 0.82 per cent. Taking the four years together, some 57,469 weevils were collected at various intervals during the fall from September to November inclusive, and placed in various types of protective shelters. Of these, 1,881 survived, the weighted average survival being 3.27 per cent (Table 1).

Rate of Emergence

Observations on the emergence of the weevil were commenced in March and continued up to July 15. During this period for the four years, 400 weevils issued during March, 786 in April, 549 in May, 144 in June and 2 in July. In 1923 and 1924, emergence was heaviest during May, but in 1925 and 1926, the largest number issued during April (Table 2).

In three of the four years, emergence in March was comparatively light, being 4.9 per cent of the total in 1926, 8 in 1924 and 9.04 in 1923. In 1925, however, it was 27.65 per cent of the total. The percentage of the total emergence in April also varied during this period from 33.48 per cent in 1923 to 53.92 in 1926. In May it varied from 20.52 in 1925 to 51.8 in 1923, and in June at was 7.6 in 1925 and 16 in 1924. July 1, 1925, two weevils issued from the hibernation cages, this representing 0.15 per cent of the total number surviving. Averages for the four years show that 12.40 per cent emerged in March, 41.86 in April, 35.68 in May, 10.01 in June and 0.15 in July (Table 2).

Per cent of Emergence Before Cotton Plants Were up

Cotton in this section was up April 17, 1923, April 24, 1924, April 21, 1925 and April 30, 1926. Therefore, 21.26 per cent of the weevils had emerged from hibernation before cotton came up in 1923, 40 per cent in 1924, 50.63 per cent in 1925 and 58.82 per cent in 1926.

Longevity of Overwintered Weevils Before Cotton Came up

In order to determine the longevity of weevils issuing before cotton came up in 1925 and 1926, as they issued from the trash in the hibernation cages they were marked with different colored dyes and replaced. When seen again, a second mark was made, and so on each day as long as they lived and were recovered.

There were 524 weevils which emerged in the field cages prior to April 21, 1925, the date at which cotton first came up. Of these, 332 or 63.23 per cent, were recovered at various dates after they were first seen. Some were observed the following day only, while others disappeared for short periods, reappearing from time to time. The longevity ranged from 1 to 52 days and averaged 5.64. In the cages in the woods, 94 issued before April 21, 64 of which, or 68.08 per cent, were seen from one to six times after the first record of their emergence from hibernation. Here the range in the length of life varied from 2 to 23 days, with an average of 4.90. For all cages in 1925, the average post-emergence longevity before cotton came up was 5.52 days.

In 1926, 46 weevils emerged in the field cages prior to April 30, when cotton was first up. Thirty of these, or 67.39 per cent, were recovered after their first emergence. In the cages in the woods 12 of the 14, or 85.71 per cent, emerging during this period lived longer than one day. For both series the maximum longevity was 23 days and the average 6.86. The average in the field cages was 5.89 and in those in the woods, 10.07 days.

The average longevity in the hibernation cages for the two year period was 5.64 days (Table 3). During both years a few weevils issuing before the appearance of cotton above ground lived long enough to feed upon the young plants, but they all died in the field cages shortly thereafter.

Per Cent of Emergence Before Fruiting of Cotton

From the time cotton comes up until it starts to develop blossom buds or "squares," the weevil cannot reproduce and has to feed on the leaves, tender stems and leaf buds. Since the plants do not square until late May or usually early June in this section, this period extends from five to seven weeks after cotton first comes up. The weevils still continue to emerge from hibernation during this time. In 1923, the first squares appeared June 14 and 99.09 per cent had emerged by this date. For the other years, the per cent of emergence at date of first square formation was as follows: 1924, 97.33 on June 10; 1925, 90.01 on May 29; 1926, 98.03 on June 7.

Longevity Before Fruiting of Cotton

In order to determine the longevity of weevils emerging from hibernation after cotton came up but before it developed squares, they were removed from the cages on the same day that they emerged, and placed in large field cages over young plants. As a check, a similar series was under observation in the insectary in tumblers, cotton leaves and leaf buds being used as food. In 1925, 165 weevils were released in field cages at weekly intervals from April 23 to May 28. Ninety-seven of these emerging from April 23 to May 9 were all dead before cotton began to square. Of the remaining 68, released from May 14 to 28, from 62 to 90 per cent were dead by the time cotton began to fruit. The average length of life was 8.01 days. In 1926, 27 weevils were released from April 17 to 28 in field cages and 96.29 per cent were dead June 7 when squares were first formed. The average longevity for this year was 8.81 days. The maximum longevity for the two-year period was 40 days and the average from 192 records was 8.12.

In 1925, 125 weevils were released in tumblers and bell jars in the insectary at intervals from April 22 to May 25. Fifty-five of these, or 44 per cent, were dead when cotton began to fruit. The average longevity was 14.56 days. In 1926, 38 weevils were released in tumblers from April 29 to June 4, and 10.52 per cent were dead June 7. The average longevity was 12.21 days. The maximum length of life for the two year period was 40 days and the average from 163 records was 14.01 (Table 4).

The greater average longevity of weevils in the insectary over that of those in the field cages indicates that conditions in the former were more favorable for the weevil. Experiments at Tallulah and elsewhere have shown that there is a difference in temperature, humidity, evaporation and amount of sunlight in a wire-screen cage as compared to these in the field, but these cages represented a nearer approach to natural conditions than the tumblers in the insectary. Later on in the season, as soon as the cotton plants were larger and were fruiting, it was possible to keep the weevils alive much longer than before in these same cages.

Per Cent of Emergence After Cotton Fruits

In 1923, 0.9 per cent emerged from the hibernation cages after the first squares formed, in 1924, 2.67; in 1925, 9.99; and 1.97 in 1926. The last weevil emerged June 19, 1923, June 25, 1924, July 1, 1925 and June 22, 1926.

Longevity After Cotton Fruits

While the weevils were very short lived in the field cages when fed on cotton prior to and often just after the plants started to square, con-

ditions were soon reached by the plant favoring these insects. There was a rapid increase in plant height and total leaf area, giving shade and protection from the sun, as well as the production of squares upon which the weevil naturally fed. The average longevity of males after square production was 21.55 days in 1924, and 13.46 in 1925. For the two-year period the maximum was 66, the minimum 2 and the average 16.28 days. The average longevity of the females in 1924 was 16.45 days, and 11.51 in 1925. For the two-year period, the maximum was 46, the minimum 2 and the average 13.42 days.

Comparison of Weevil Survival in Field and Woods

In 1925 and 1926, a series of hibernation cages was under observation in a pine woods flat in order to determine whether the protection afforded by the trees and undergrowth would have any effect upon the number of weevils surviving the winter. It was found that there was a difference in the percentage surviving in the two series of cages during the two years as follows: In 1925, 7.6 per cent survived the winter in pine straw trash in the field and 10.98 per cent in the woods; in 1926, the survival in the woods was 0.42 and in the field 1.2 per cent. Thus, one year, more weevils survived in the field cages and the other year more in the woods cages. It is therefore difficult at the present time to determine which of the two locations is representative of what actually happens.

Comparison of Emergence in Field and Woods Cages

In 1925, the emergence from the field cages by monthly periods was as follows: March 31, 23.7 per cent; April 30, 65.18 per cent; May 31, 94.00 per cent; and June 17, 100 per cent. That year the rate of emergence from the woods cages was slower as is shown by the following figures: March 31, 21.3 per cent; April 30, 56.25 per cent; May 31, 75.39 per cent; and July 1, 100 per cent. In 1926, none issued from cages in either location during March; April 30, 82.35 per cent had emerged in the woods as compared to 45.83 per cent in the field. Emergence was completed May 24 in the former and June 22 in the latter. It is thus seen that in 1925 and 1926, there was a difference in the rate of emergence of the weevil from hibernation cages located in the two situations, one year field cages accelerating emergence and the other retarding it.

Migration of Overwintered Weevils to Cotton as Determined by Trap Crops

In addition to determining the rate of emergence from hibernation by the aforementioned cage experiments, we decided to find out when

weevils were actually migrating to the cotton fields in the spring, by the use of trap plants. Two small plats were planted early in April 1925. One of these was situated on the edge of a tobacco field and the other in a peach orchard. Both locations were chosen because they bordered wooded areas, where heavily infested cotton had been the year before and were isolated as far as possible from other cotton fields. The first of these trap crops comprised a tenth of an acre and was about 200 yards from the nearest cotton. The second had four rows, each approximately 50 feet long and was at least one-half mile from the nearest cotton. All plants were carefully examined every morning except Sunday, and if any weevils were found, they were removed, counted, and the sex determined. A total of 134 were collected from both plats from May 14 to July 6. Of these, 63 were removed by May 29, at which date the oldest plants were beginning to develop blossom buds. This represented 47.01 per cent of the total emergence in these plantings at a time when there was an average of 0.035 squares per plant. On June 15, when there was an average of 1.6 forms per plant, 76.11 per cent of the total emergence had been recorded in these plats (Table 5).

Weevil counts made in different fields in widely separated localities around Florence showed a slight but steady increase in the weevil population from week to week from the time cotton was thinned up to the appearance of the earliest first-generation weevils. This increase can be accounted for by the fact that overwintered weevils were still coming into cotton from hibernation, a fact which checked up with trap-crop records.

The trap-crop records show that in 1925 there was a considerable emergence after plants began to fruit and also that there were two distinct periods when large numbers of weevils were leaving hibernation and entering cotton fields, namely, from May 14 to May 26, and from June 11 to June 22. Another interesting fact is that while these insects had been emerging from hibernation cages ever since March 6, none were found in either plat until May 14 or 15, in spite of the fact that cotton in these was up by April 23.

In 1926, two similar plats were under observation but the emergence was so light that few data were obtained. In one planting no weevils were found and in the other, four from June 24 to June 30. In both years emergence was mostly over by June 30 at about the time the first blooms appeared.

Comparison of Emergence as Recorded by Hibernation Cages with That in Nature as Determined by the Trap Crop

In 1925, weevils issued from hibernation cages in the woods and were collected from the two trap crops on about the same dates after May 14. On the other hand, emergence in the field cages did not check up with either of the above after this date. During that year, 90.01 per cent of the surviving weevils had emerged from all cages when cotton began to square, 73.04 per cent in those located in the woods, 90.37 per cent in the field and 47.01 per cent in the trap crops. In 1926, 98.03 per cent had emerged in all hibernation cages when cotton began to square, all

Table 1. Survival of Overwintered Weevils at Florence, S. C., 1922–1926

Year	Number of weevils installed	Number of weevils survived	Per cent of weevils survived
1922–23	4,000	442	11.05
1923–24	21,617	75	0.34
1924–25	19,427	1,262	6.49
1925–26	12,425	102	0.82
1922–26	57,469	1,881	3.27

Table 2. Number and Per cent of Surviving Weevils Emerging by Months at Florence, S. C., 1923–26

Year	March		April		May		June		July	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1923	40	9.04	148	33.48	229	51.80	25	5.65		
1924	6	8.00	27	36.00	30	40.00	12	16.00		
1925	349	27.65	556	44.05	259	20.52	96	7.60	2	0.15
1926	5	4.90	55	53.92	31	30.39	11	10.78		
Total and average	400	12.40	786	41.86	549	35.68	144	10.01	2	0.15

Table 3. Longevity of Overwintered Weevils Emerging Before Cotton Came Up, Florence, S. C., 1925–26

Year	Total number of weevils emerged before cotton came up	Maximum post-emergence longevity	Total number weevil days	Average post-emergence longevity
1925	618	52 days	3,416	5.52 days
1926	60	23 "	412	6.86 "
1925–26	678	52 "	3,828	5.64 "

Table 4. Longevity of Overwintered Weevils in Cotton Before Fruiting, Florence, S. C.

Year	Number of records		Maximum days longevity		Number weevil days		Average days longevity	
	Field	Insectary	Field	Insectary	Field	Insectary	Field	Insectary
1925	165	125	37	38+	1,322	1,820	8.01	14.56
1926	27	38	40	40+	238	464	8.81	12.21
1925–26	192	163	40	40+	1,560	2,284	8.12	14.01

TABLE 5. DAILY COLLECTIONS OF WEEVILS IN TRAP CROPS, FLORENCE, S. C., 1925

Date	Number weevils collected	Accumulated emergence	Per cent of emergence	Average number of squares per plant
Apr. 23 to May 13	0	0	0	0
May 14	9	9	6.71	
May 15	5	14	10.44	
May 16				
May 18	7	21	15.67	
May 19	2	23	17.16	
May 20	2	25	18.65	
May 21	9	34	25.37	
May 22	7	41	30.59	
May 23	9	50	37.31	
May 25	8	58	43.28	
May 26	3	61	45.52	
May 27	1	62	46.26	
May 28				
May 29	1	63	47.01	0.035
May 30	1	64	47.76	
May 31				
June 1	4	68	50.74	
June 2	5	73	54.47	0.09
June 3	2	75	55.97	
June 4				
June 5	1	76	56.71	
June 6	1	77	57.46	
June 8	2	79	58.95	0.49
June 9	4	83	61.94	
June 10				
June 11	4	87	64.92	
June 12	2	89	66.41	
June 13	2	91	67.91	
June 15	11	102	76.11	1.6
June 16	8	110	82.08	
June 17	3	113	84.32	
June 18	6	119	88.80	
June 19	1	120	89.55	
June 20	3	123	91.79	
June 22	5	128	95.52	
June 23	1	129	96.26	
June 24				4.4
June 25	3	132	98.50	
June 26				
June 27				
June 28				
June 29				
June 30				
July 1				8.3
July 2	1	133	99.25	
July 3				
July 4				
July 6	1	134	100.00	

had issued in those located in the woods, 97.91 per cent in those in the field, and none had been collected in the trap crops.

The emergence from the hibernation cages is called the "total emergence" and that in the trap crops the "effective emergence." The latter represents those weevils that issue from hibernation late enough to find cotton before dying of starvation or other causes. It has been found that the rate of emergence of weevils in hibernation cages varies in different years according to the location of the cages and to some extent with the type of shelter in the cage. As a result the data secured by means of the trap crops is considered more reliable because it actually represents field conditions.

PRESIDENT ARTHUR GIBSON: We will now listen to a paper by J. M. Robinson.

THREE YEARS OF BOLL WEEVIL CONTROL ON ONE TWENTIETH ACRE PLOTS, WITH VARIOUS RATES OF FERTILIZERS

By J. M. ROBINSON, *Auburn, Ala.*

(Withdrawn for publication elsewhere)

MR. W. E. HINDS: Possibly Professor Robinson might have brought out a little more clearly that this was an old cotton farm where the fertility of the soil had been almost exhausted, as I am sure you could see from those unfertilized rows. (Exhibited in lantern slides.) Under those conditions and under a dry season with a high degree of moisture control, there was little room for poisoning to show a normal profit. The figures there as to the gain from poisoning in a season of average rainfall will probably be about the average for the entire cotton belt, and as your productive capacity increases, the saving from poisoning also increases and becomes more profitable, but one of the most interesting things to me in the figures shown on the screen was the absolute proof that in a dry season there is no cross feeding from one row to another, even with rows planted three and a half feet apart, as I think was the distance in this case, where the next row had as high as 1500 or 2000 lbs. of fertilizer to the acre. That unfertilized row, as you noticed, was very striking indeed.

PRESIDENT ARTHUR GIBSON: The next paper is by L. L. Huber and C. R. Neiswander. Mr. Huber read the paper.

THE EUROPEAN CORN BORER AND ECOLOGICAL HABITATS

By L. L. HUBER and C. R. NEISWANDER, *Ohio Agricultural Experiment Station, Wooster, Ohio*

ABSTRACT

This paper constitutes a report of one phase of the European corn borer (*Pyrausta nubilalis* Hübn.) project in Ohio. The information contained herein consists of the using of vegetative types as indices of certain atmospheric and edaphic factors that are thought to greatly influence the behavior of the corn borer. An attempt is made to show that up to the present time the corn borer has accumulated most rapidly and has occasioned most severe damage in certain restricted areas.

Since the introduction of the European corn borer (*Pyrausta nubilalis* Hübn.) into Ohio, yearly surveys have been made to determine the rate of accumulation of the insect in previously infested areas. In addition to and in conjunction with the regular survey, Dr. E. N. Transeau and Dr. H. C. Sampson of the Ohio State University conducted, during the past summer, an ecological survey of certain vegetative types in Ohio and all other regions infested by the corn borer, exclusive of New England. In this paper an attempt is made to point out the correlation between the ecological data and infestation records.

This joint survey was greatly facilitated by the generous cooperation and services of Mr. H. G. Crawford of Canada and Dr. E. P. Felt of New York. Others actively assisting in the project were Mr. E. G. Kelsheimer and Mr. J. B. Polivka of the Ohio Station.

Infestation data in Ohio since the beginning of investigational work have indicated certain areas where the percentage of infestation has been consistently high and other areas where it has been consistently low. Detailed data relative to the accumulation of the insect in areas outside of Ohio are not available, but from reliable information given by federal and state investigators and from personal observations it is known that there are regions in New York, Pennsylvania and Michigan where similar conditions obtain. (See map, Figure 13.) It is a matter of general knowledge that the infestation in the Schenectady region in New York has been and still is considered almost negligible; damage has occurred only over a few hundred acres. On the contrary, in the Silver Creek, New York, region the infestation has long since accumulated to the point where serious losses have occurred over extensive areas. Similar conditions of infestation, although less marked, exist in Pennsylvania and Michigan.

Detailed infestation data permit a more thorough discussion of the conditions in Ohio. In 1921 Federal scouts discovered the corn borer

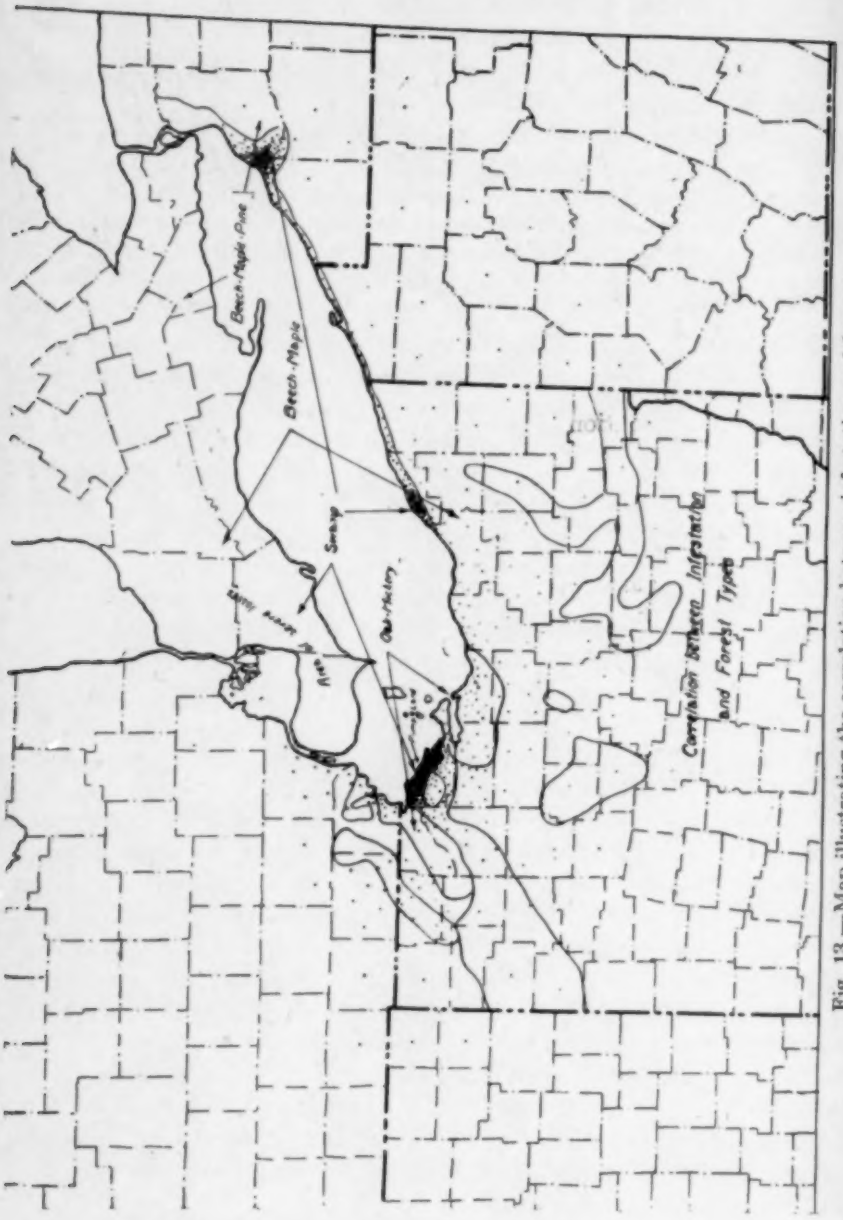

Fig. 13.—Map illustrating the correlation between infestation and forest types.

in every township along the border of Lake Erie. This territory has been scouted wholly or in part every year since 1921. The records for 1922 were meager but, even so, there was already some evidence of a tendency to accumulate in certain areas. The records for every year since 1922 have indicated a pronounced tendency for accumulation at certain points. The infestation map (Figure 13) indicates a narrow strip in the vicinity of Painesville in northeastern Ohio that has for four years maintained a consistently high infestation; whereas the adjacent area just south has had a consistently low infestation. The average borer population per acre for this narrow strip bordering the Lake is about 10,000, but the average borer population per acre for an area of equal width immediately south is not more than 400, or a ratio of 25 to 1. In northwestern Ohio a more marked contrast exists. The average borer populat. .. in the Bono area east of Toledo as compared with the average west of Toledo is in a ratio of 45 to 1. The general territory centering around Sandusky in Erie County has a somewhat similar history. The infestation in the Bono region is in a ratio of 17 to 1, as compared with the Sandusky region.

The following data will serve to point out the approximate rate of accumulation of the insect in the regions east and west of Toledo. In the Bono area the maximum borer population per acre in 1923 was about 1500; in 1924 it was about 4000; in 1925 it was about 13,000; and in 1926 it was about 80,000. However, in the area immediately west of Toledo where the infestation is of just as long duration as at Bono, there has been no such tendency to accumulate. The present maximum infestation west of Toledo is probably not more than 2000 borers per acre, as compared with 80,000 per acre to the east.

It is an undisputed fact, therefore, that up to the present time the accumulation and the degree of infestation of the corn borer has not been equal in all areas. In the six to eight years that have elapsed since the introduction of the insect the highest infestation, the most rapid accumulation and the most severe damage to corn have occurred in certain restricted regions as indicated.

According to Transeau "Our best measure of habitat conditions in a restricted region is the vegetative type." "In the present corn borer region the original forests consisted principally of three types: (1) the Oak-Hickory Forest; (2) the Beech-Maple Forest; and (3) the Swamp Forest."

"The Oak-Hickory Forest (when original) is generally found in drier areas, either because of dry climatic conditions, or because of over-

drainage, or a combination of both. The Beech-Maple Forest usually represents more moist conditions, both of atmosphere and soil. The Swamp Forest—Elm, Ash, Maple, Swamp White Oak, Pin Oak and Hickory—is typical of areas with a high soil water table and constantly humid conditions."

The purpose of the joint ecological and insect survey was an attempt to discover, if possible, an ecological index to the degree of infestation. The survey included the region from Niagara Falls to Windsor and Sarnia and from Detroit around the Lake, to Buffalo and Schenectady. It was noted that the Swamp Forest is dominant over the extreme western portion of Ontario, a part of northwestern Ohio, and the territory directly adjacent to the Lake in northeastern Ohio, Pennsylvania and New York. Closely associated with the Swamp type is the Beech-Maple or the Beech-Maple-Pine types which abound on the uplands, the latter type being dominant in eastern Ontario and in the Silver Creek region. The Schenectady area, not shown on the maps, is primarily a Beech-Maple habitat, although the Swamp type abounds over two or three hundred acres in the river valley. The third type of forest, or Oak-Hickory, dominates the Sandusky region, and the area immediately west of Toledo. In this connection, however, it is well to point out that there may be local or restricted habitats of a different nature within the general habitat regions, as indicated on the map. For example, within the Oak-Hickory habitat about Sandusky there are restricted Swamp areas.

The following map (Figure 13) illustrates the extent of correlation of forest types with infestation records. It is shown here that the most rapid accumulation of the corn borer has occurred rather uniformly in regions where the Swamp Forests are dominant and where Beech-Maple is the upland type. On the other hand the least rapid accumulation has occurred on the higher lands where the Oak-Hickory or Beech-Maple-Pine types are dominant. Furthermore it may be of interest to note that the heaviest infestation in Ohio occurs in an area that consists largely of reclaimed swamp lands.

The above correlation is offered here only as information; it is not explanatory. The explanation is the subject of present and future research. Unlike many other ecological studies, no detailed meteorological records are involved. This study consists in the using of vegetation types as indices of certain atmospheric and edaphic factors which have been at work for a long period. Evidently the same factors that have determined the type of vegetation in restricted areas are also

influencing the accumulation of the corn borer in similar restricted regions. Inasmuch as the survey is still incomplete, no definite conclusions can be drawn. But if the behavior of the insect, since its introduction into the areas mentioned, is any criterion of its future behavior, then it is not too much to expect that its control will be more difficult in some areas than in others. And the sooner we know where these areas are the more intelligent will be our attack.

PRESIDENT ARTHUR GIBSON: The next is a paper by L. S. McLaine and H. G. Crawford.

Mr. McLaine read the paper.

THE STATUS OF THE EUROPEAN CORN BORER IN CANADA (1926)

By L. S. MCLAINE and H. G. CRAWFORD, *Entomological Branch, Ottawa*

ABSTRACT

During 1926 the European corn borer, *Pyrausta nubilalis* Hübn., spread in Ontario into sixty additional townships. The infested area now covers approximately thirty-five thousand square miles. The most easterly infestation is 375 miles from the original outbreak in Elgin county, and the most northerly 250 miles from the same district. In addition two infestations widely separated have been uncovered in the province of Quebec, both being due to natural spread.

With the exception of a small area, where much extension work has been carried on, there has been a decided increase in the amount of infestation in Ontario. The 400 square mile area severely devastated in Essex and Kent Counties in 1925, increased to 1200 square miles in 1926.

The infestation in Quebec is exceedingly light.

Control operations are now being carried out in the eight most heavily infested counties in Ontario, under the supervision of the provincial authorities.

During the past season the European corn borer has continued to spread into new territory until now it infests practically the entire corn growing districts of the province of Ontario and has also invaded the province of Quebec.

Although this past summer has been regarded as one of unusual coolness, greater precipitation, and of shorter duration than the average, this pest has spread over more territory than was the case last year. One or more collections of European corn borer larvae were made in sixty additional townships in Ontario last season as compared with twenty-five in 1925 and five in 1924. The infested area in this province may be said to extend from the Quebec boundary on the east, to Lake Huron and the Detroit River on the west, and south of a line from the city of Ottawa to Parry Sound on the north, and covers roughly thirty-

five thousand square miles. At the present time 333 townships are infested or under quarantine, this number will be increased later in the season when the quarantine regulation is revised and townships not found infested but adjacent to infested ones are included for economic reasons. The most easterly infestation found this past season is about three hundred and seventy-five miles from the original outbreak in Elgin county. Mention should be made of the isolated infestation found at North Bay on Lake Nipissing in Nipissing county. This outbreak is of particular interest on account of its northern position, being approximately two hundred and fifty miles north of the original outbreak at St. Thomas. From the information available it would appear that with the exception of the outbreak at North Bay, the increase in the infested area is due to the natural spread of the insect. As regards North Bay, the infestation is undoubtedly due to infested corn being carried or shipped from the infested area. Although every effort has been made to prevent the illegal shipping of corn, the financial returns were apparently too strong for unscrupulous individuals to resist, as early table corn is sold at a good premium in the northern districts.

The outbreak in Quebec which occurs at two different points is due to natural spread. One of these occurs in two townships in Hull County and one in Papineau County just north of and across the Ottawa river from the city of Ottawa. The second outbreak is in south western Quebec just north of the state of New York, and is due undoubtedly to spread from the infestation which has occurred in northern New York. About two hundred square miles are involved in the three townships in the Hull area and five hundred and fifty square miles in the south western area which includes portions of Chateauguay, Huntingdon and St. Johns counties.

Intensity of Infestation

For the fourth successive year certain definite points were selected throughout the infested area to determine the increase or decrease in the amount of infestation. The points are fixed and three hundred corn stalks in each of the five corn fields nearest to the so called "point" are examined. Only the percentage of stalk infestation was taken, time would not permit the recording of the larval population per stalk. Records were taken at eighty-nine different points in 1926.

The locality points selected may be divided into two distinct groups, first those on a series of three concentric circles, seven, fifteen and thirty miles respectively from Union as a centre, which was the centre of the initial and severe infestation, and known as circles Nos. 1, 2 and 3;

and second, points selected at different localities in various infested counties.

The average stalk infestation in circle No. 1 (seven miles from Union) showed a decrease in both 1925 and 1926, a reduction of from forty to thirty per cent occurring this year. It should be noted that in this area intensive educational and demonstration campaigns have been carried on, sweet corn as a crop has been practically discontinued and the greater portion of the main corn crop is ensiled. In circle No. 2 (fifteen miles from Union) there has been an increase of from thirty-two to thirty-nine per cent; and in circle No. 3 (thirty miles from Union) the stalk infestation has increased from eleven to twenty-nine per cent. The three great corn growing counties continue to show a marked increase, Kent increasing from fifty-three to seventy-nine per cent; Essex from thirty-eight to eighty-three per cent and Lambton jumped from five to thirty-four per cent, north-west Middlesex county which adjoins Lambton, showed an increase of from four to twenty-nine per cent.

In the paper presented last year it was stated that in an area covering approximately four hundred square miles along the Kent-Essex counties line, the corn was a complete loss, in 1926 this area was increased to approximately twelve hundred square miles. Extensive loss also occurred westward from this area to the Detroit river and northward into the southern part of Lambton county.

The European corn borer is also increasing rapidly in numbers in several other counties; mention may be made of Welland which was first found infested in 1920; for a number of years the increase was by no means rapid, but this past season it rose from twelve to twenty-eight per cent.

Prince Edward County is an isolated peninsula extending into Lake Ontario about one hundred miles east of Toronto; it is a large corn growing county and ninety-five per cent of the crop is grown for canning purposes. A very light infestation was discovered in this county in 1924; this year the general average was about two per cent, but in some fields as high as ten per cent infestation was found. Apart from the districts mentioned the European corn borer infestation remains still so light that no serious damage was done in 1926.

The infestation in the two infested sections in the province of Quebec is very light at the present time, being much less than one per cent.

CONTROL

In the most heavily infested sections of Kent and Essex counties there has been a very decided decrease in the amount of corn acreage

planted and from the information available at this time it would appear that the acreage would be still further reduced in 1927.

The actual control operations in the province of Ontario are under the jurisdiction of the Provincial Department of Agriculture. On July 20th, 1926, regulations were passed under the European Corn Borer Act of 1926. In accordance with these regulations it is the duty of every person growing corn in the counties to which the Act has been made effective, to adopt such methods in the growing of corn and in handling the land and the remnants of the crop as will most effectively control the corn borer. The regulations further define as to the action that must be taken by the owner or occupier of the land in handling the crop, crop remnants, stored corn, and the tillage of the soil for crops following corn, etc. Inspectors are appointed to see that the regulations are carried out and if an occupant neglects or refuses to carry out the instructions of the inspector, the latter may carry out the control operations, in which case the expense so incurred shall be entered on the collector's roll and be collected in the same manner as taxes. This law has been made to apply to eight counties and inspectors were appointed early in the fall to see that the regulations are being duly carried out. The counties affected are: Essex, Kent, Lambton, Elgin, Middlesex. Norfolk, Oxford, and Prince Edward.

PRESIDENT ARTHUR GIBSON: We have one more paper on the European corn borer.

THE EUROPEAN CORN BORER IN WEEDS AND TRUCK CROPS IN OHIO

By C. R. NEISWANDER and L. L. HUBER, *Ohio Agricultural Experiment Station, Wooster, Ohio*

ABSTRACT

This paper gives the results of an experiment in which corn borers, *Pyrausta nubilalis* Hübn., were reared on plants other than corn, together with the statement of field records on the number of larvae found in weeds in heavily infested corn fields.

Investigators studying the European corn borer (*Pyrausta nubilalis* Hübn.) in Ohio are continually being asked the question why at the outset the government did not forbid the growing of corn for a year or two in the infested area around Lake Erie and thus effectively exterminate the borer. In answering a question of this kind entomologists have been hampered somewhat by lack of data although all were convinced of the futility of such a procedure. For instance, there is no reason for assuming that the corn borer is not entering and will not continue to

enter the Ohio region each year in the same manner in which it came originally. Since the infestation across Lake Erie has increased enormously the probability is great that the number of moths entering the United States each year is normally much greater than were those responsible for the original infestation.

A still further indication of the futility of this plan, and one with which this paper deals, is the probability that the corn borer would not be exterminated if corn were completely lacking as a source of food material. It has been demonstrated a number of times in laboratories that corn borer moths can be forced to deposit eggs on almost any plant and even on other materials. This means that if corn borer moths were unable to find corn, due to the restriction of corn growing in the infested areas by governmental action, the moths already there would most certainly deposit their eggs on other plants or other materials as they do where corn is not available as in cages. The problem then remains to determine whether any of these eggs so deposited would develop to mature moths.

Weed and Truck Crop Cage—1925

During the summer of 1925 a large cage fourteen feet by sixteen feet and seven feet high enclosed by 12 mesh wire cloth was used as a general truck and weed experimental cage. In it were grown a great variety of garden and truck crops; and most of the common weeds as well as field and sweet corn. A large number of moths were permitted to emerge within this cage and deposit eggs as they would. An examination of the plants at the height of the egg laying period showed that egg masses had been deposited on the following plants: pigweed, spanish needle, turnip, bean, radish, celery, sweet corn, field corn and gladiolus. A subsequent examination made on July 28 showed that the following plants were or had been infested: common ragweed, pigweed, smartweed, lamb's quarters, foxtail, barnyard grass, round-leafed mallow, spearmint, velvet leaf, curly dock, radish, bean, potato, red beet, tomato, celery, sweet corn and field corn. Growing promiscuously as these plants were it can by no means be assumed that the larvae developed in the plants on which they were originally deposited as eggs. But since the examination was made before any of the larvae had ceased feeding, the test shows that the larvae were able to feed in some stage of their development on the above named plants.

Subsidiary to this experiment, cages were run on individual and isolated plants of a few common species, the plants being left to stand throughout the season. Five female and five male moths had been placed

in each cage. The plants used were smartweed, pigweed, cocklebur, potato, and tomato. The number of eggs deposited on them varied from six to twenty-seven egg masses. Since the plants were not dissected or disturbed until the end of the season it could not be definitely stated that borers had made their complete development on any of the plants, but from the fact that the plants were somewhat isolated, from the nature of the injury to the plants when examined, and from the borers found when the plants were dissected, smartweed and cocklebur seem to have been satisfactory hosts. In the potato plant there were a few short tunnels but no borers were found, while in pigweed, tomato, and lamb's quarters there was no positive evidence of corn borer feeding, and the indications were that these plants did not serve as complete hosts as far as this test was concerned.

Corn Borer Host Experiment—1926

As a consequence of the above indications a further and more complete test was planned for the following season. A number of plants of the different species selected for study were grown in plots, each consisting of three rows five hills long with a seven foot interval between plots to lessen the chance of migration. The species of weeds used in the test were cocklebur, *Xanthium canadense*, giant ragweed, *Ambrosia trifida*, pigweed, *Amaranthus retroflexus*, smartweed, *Polygonum* sp., and velvet leaf, *Abutilon theophrasti*. In addition to these there was also a plot of celery, potato, broom corn, sorghum, field corn, and dahlia. As an extra precaution to prevent migration from the corn to any of these plants the corn plot was entirely surrounded by the usual type of barrier used in our corn borer experimental work.

Cylindrical wire cloth cages approximately two feet high were placed over the plants. Usually five males and five females were placed in each cage, the number included depending somewhat upon the moths available at the time the cages were started, the object being to have enough moths to produce a sufficient number of eggs for a significant record. New cages were started every few days throughout the period of the experiment. The cages were left on the plants about five days or until just before time for the first eggs to hatch. They were then removed and the egg masses and eggs counted.

In order to be sure that the larvae were living in these plants at all stages dissections of plants in all plots were made at intervals beginning July 30 or about twenty days after the first eggs were deposited. The number of larvae and the instar in which they occurred at the time of dissection was recorded in every case. Below are given charts with the

type of information taken. In order to conserve space the record of just three hosts is given in complete form.

DISSECTION RECORD OF THREE HOST SPECIES

Host	Mating date	Removal date	Eggs deposited	Dissection date	Larvae taken by instars 1st	2nd	3rd	4th	5th	6th	Total	Per cent recovered	Remarks
Smartweed	7– 6	7– 9	125	7–30	8	15	9	3			35	28.0	See note [1]
	7– 8	7–13	1241	8– 9		2	4	5	3		14	1.1	
	7– 7	7–12	148	8–18					1	1	2	1.3	
	7–15	7–20	456	8–28						5	5	1.1	
	7–13	7–19	722	9– 6					1	6	7	0.9	
	7– 9	7–14	226	9–14						3	3	1.3	
Total			2918								66	2.26	
Giant ragweed	7– 8	7–13	860	7–30	26	9					35	4.0	See note [2]
	7– 9	7–14	675	8– 9	1	3	3	1	1		9	1.3	
	7–13	7–19	1281	8–18				2	3	5	10	0.9	
	7–14	7–20	1211	8–30						27	27	2.2	
	7–13	7–19	661	9– 6						9	9	1.3	
	7–10	7–16	613	9–14						9	9	1.4	
Total			5301								99	1.87	
Pigweed	7– 6	7– 8	335	7–30							0	0	See note [3]
	7–13	7–19	1000	8– 9							0	0	
	7– 8	7–13	552	8–18							0	0	
	7–15	7–20	365	8–30							0	0	
	7– 8	7–13	293	9– 6							0	0	
	7–12	7–19	277	9–14							0	0	
Total			2822								0	0	

[1] Very marked injury.
[2] A few leaves and branches wilted from injury
[3] One dead larva of 1st instar found.

It may be noted that in case of smartweed, at the time of the first dissection larvae were taken in each of the first four instars. In the second dissection they were found in the second to fifth instars and in the remaining four dissections only in the fifth and sixth. Practically the same records may be noted for the giant ragweed. This seems to show that without doubt borers lived in these two species from egg to full grown larvae. On the other hand, in case of pigweed, no borers of any instar were found in any one of the six dissections in spite of the fact that nearly three thousand eggs had been deposited upon these plants. This seems to be contrary to field records since this species is a rather common host of the corn borer in badly infested corn fields. However, the borer had been found in pigweed in the field only from the fourth

instar on, the inability to feed on it apparently occurring in the first and second instars.

In the chart below is given a compiled record of the recoveries from all hosts studied. It may be noted that smartweed and dahlia have a higher percentage of establishment than has corn, while giant ragweed is just a little below it. Cocklebur also has a comparatively high establishment record, though perhaps not as high as might be expected normally since the plants used in the experiment were small and poorly developed at egg laying time. In heavily infested corn fields this last named weed is very commonly infested.

Broom corn and sorghum are shown to be very poor hosts. Of the nineteen larvae taken from these plants during the course of the experiment none were found within the stalk, all of them occurring in the crown of the plant in early dissections or behind the leaf sheath in later ones. One tunnel was seen in sorghum but it was of small size and full of a viscous secretion. In both of these species less than one-half of one per cent of the eggs deposited were recovered as larvae and only three of these were taken as full grown larvae. This record is analogous to field records for these crops in Ohio, as to date no full grown larvae have been taken from either when grown in our experimental plots in the midst of the heavily infested area at Bono, Ohio.

The results of the experiment indicate that if eggs were deposited on smartweed, ragweed, or dahlia the borers would develop as well, and on cocklebur nearly as well as on corn. The larval mortality was high in broom corn, sorghum and celery; nevertheless a few larvae were found in several dissections of each. The remaining species studied, namely, celery, potato, velvet leaf, and pigweed seem to be of no importance as primary hosts of the corn borer as it behaves in Ohio under present conditions.

While the establishment record for the larvae on these plants as given above is low when compared to the establishment sometimes recorded in fields of corn, it must be noted that the establishment on the corn plot used as a check was also low, in a few of the cases cited being slightly lower even than that of the weeds.

Field Records

Supplementary to the experimental studies made in weeds and truck crops at the laboratory, observations were made repeatedly in the field. During the egg laying period corn borer moths were commonly seen amid weeds of different species at the margins of corn fields, pigweed, *Amaranthus retroflexus*, being quite conspicuous in these localities. In

RECORD OF DISSECTIONS MADE IN DIFFERENT HOSTS STUDIED

Host	No. of dissection dates	No. of times larvae were taken	No. of eggs deposited	Instar record of larvae taken in all directions						Total	Per cent of recovery	Remarks
				1st	2nd	3rd	4th	5th	6th			
Smartweed (*Polygonum* Sp.).....	6	6	2918	8	17	13	8	5	15	66	2.26	Very marked injury
Dahlia.....	5	5	3302	9	15	10	11	4	24	73	2.21	A good host Injury very severe—A good host
Corn (*Clarage*).....	6	6	1777	2	1	1	1	1	33	39	2.19	Considerable leaf injury
Giant ragweed (*Ambrosia trifida*).	6	6	5301	27	12	3	3	4	50	99	1.87	Some leaves and twigs wilted
Cocklebur (*Xanthium canadense*)	5	3	903	0	1	2	4	2	1	10	1.11	Plants not thrifty—injury in every dissection
Sorghum.....	6	4	2759	2	1	1	4	3	1	12	.43	Very slight injury
Broom corn.....	5	4	2480	3	0	0	0	2	2	7	.28	Very slight injury
Celery.....	6	1	2129	0	0	0	0	0	1	1	.04	
Potato.....	5	0	671	0	0	0	0	0	0	0	0	No traces of feeding observed
Pigweed (*Amaranthus retroflexus*).	6	0	2822	0	0	0	0	0	0	0	0	Traces of slight feeding by first instar larvae
Velvet leaf (*Abutilon theophrasti*).	4	0	364	0	0	0	0	0	0	0	0	No traces of feeding observed

spite of careful search no eggs were found on any of these plants although dozens of moths could be flushed while walking through them. During the hot part of the day the insects could be seen much more commonly here than in the corn field on the corn plants.

On August 10, 1926 field dissection of weeds for early instars resulted in the finding of a number of partially grown larvae as indicated in the chart below.

RECORD OF PARTIALLY GROWN LARVAE COLLECTED IN WEEDS IN A CORN FIELD AT BONO

Host	Third instar	Fourth instar	Fifth instar
Pigweed		5	2
Smartweed	2	9	7
Cocklebur	1	3	2

It is assumed that these larvae developed from eggs that had been deposited on corn, which, after feeding through the first and perhaps the second instar either crawled or were carried by their balloooning habit to the neighboring weeds.

A study was made of the percentage of weeds infested in some of the fields most severely attacked by the corn borer during the summer of 1926. In making these investigations the plants of one species were taken consecutively by the observer as he walked through the field. Later, however, due to the increased wetness of the season there was an abnormal growth of weeds, many of them being too small for tunneling. Consequently during the latter part of the year only the larger weeds were considered in the count.

An average of several counts made in an especially heavily infested and very weedy field gave the results shown in the table below.

WEED INFESTATION IN FIELD NO. 1

Species	No. plants examined	No. plants infested	Per cent infested
Smartweed	35	23	65
Cocklebur	35	19	54
Pigweed	60	21	35
Lamb's quarters	25	4	16

In order to determine the number of borers per acre in some of the most weedy and most heavily infested fields examinations of weeds in several square rods were made with the results given below. These fields are not cited as average fields for the heavily infested region but are merely given to show what may occur in very weedy fields. In most of the heavily infested fields studied the weeds were negligible because the fields were kept clean. The first two columns in the chart below show the stalk infestation in corn in these fields and also the borer population per infested stalk in order to correlate the number of borers

in the weeds with the number present in the corn field. Although these fields were not owned by the same man the same general type of cultivation was maintained and the weed growth was enormous.

CHART SHOWING NUMBER OF BORERS PER ACRE IN WEEDS IN THREE HEAVILY INFESTED FIELDS

Field	Corn stalk infestation	Borer population per stalk	Sq. rds. examined for weed infestation	Borers per sq. rd. in weeds	Borers per acre in weeds
1	98.2	8.2	3	14.3	2293
2	90.0	3.8	5	7.2	1152
3	81.5	3.6[1]	5	4.2	672

[1]Approximated.

That these borers will have to be considered as an important source of reinfestation is evidenced by the fact that the twenty-two hundred borers per acre in field number one, if permitted to survive, would produce approximately sixty thousand borers per acre next year or just about what the field contained per acre this year when from twenty-five to forty per cent damage occurred. That is, if all the borers within the corn stalks were killed, which is practically impossible, there would still be sufficient surviving larvae in the weeds to produce an equal infestation the following year. Incidentally it may be pointed out that clean culture is a factor in corn borer control.

CONCLUSION

1. Weeds and truck crops are not known to be hosts of the European corn borer in Ohio at the present time except in or adjacent to heavily infested fields.

2. Several species of plants other than corn are potential hosts of the corn borer should eggs be deposited thereon.

3. Some of the more heavily infested corn fields in the Bono, Ohio, area have a high weed infestation, there being as high as two thousand borers per acre in weeds alone.

4. Neither eggs nor larvae younger than the third instar have been found on or in these plants in the field, hence it is assumed that the half grown or full grown larvae found in weeds have migrated from nearby infested corn plants.

PRESIDENT ARTHUR GIBSON: The next paper is by W. E. Hinds and Herbert Spencer. Mr. Hinds read the paper.

AIRPLANE DUSTING FOR SUGARCANE BORER CONTROL IN LOUISIANA

By W. E. HINDS and HERBERT SPENCER, *Louisiana Experiment Station*

ABSTRACT

The sugarcane borer (*Diatraea saccharalis crambidoides* Grote) inflicts an average damage of about 20% on the sugarcane crop in Louisiana. No practicable plantation methods for controlling this pest have become adopted or practiced to any considerable extent by the cane growers. Insecticidal treatment with arsenicals appears to be ineffective.

The recent development of the insecticide dusting airplane has provided a practicable means for treating such a crop as sugarcane, and applications of sodium silicofluoride have given a fairly satisfactory degree of control of the borer larvae, including the first and second stages while they are feeding in the leaf roll and the older stages even after they have bored into the heart of the cane.

In the treatment of thirteen hundred (1300) acres of cane by this method in 1926, the borer infestation appears to have been reduced by 60% from a single application and where observations were made about six weeks after the treatment. This allowed time for one more generation to develop. A dosage of from fifteen (15) to twenty (20) pounds per acre was required. These results are considered very encouraging and the work will be continued in 1927.

The most important insect enemy of sugarcane in this country is the sugarcane moth borer, or cane borer as it is commonly called. The species is *Diatraea saccharalis* Fabr. Some authors add the varietal name *crambidoides*.

In general appearance, and in the type of damage inflicted, this species resembles closely the larger corn stalk borer (*Diatraea zeacolella*) which attacks corn, sugarcane and some grasses but the latter species occurs through a much wider range in the Gulf States than does the genuine cane borer. There are at least three other species of Diatraea which occur in Louisiana and may be mistaken for the sugarcane borer. The larva also bears a rather close resemblance in size and in appearance to the European corn borer (*Pyrausta nubilalis*).

The sugarcane borer attacks sugarcane primarily, but is also a serious pest on corn and sorghum and frequently attacks rice, Johnson grass and several other species of large-stemmed, wild grasses growing within its range of distribution.

The problem of controlling the sugarcane borer has been under nearly continuous investigation for more than thirty years. In this time a great deal has been learned about the species but no measure of artificial control that has been previously recommended has become adopted and practiced to any considerable extent by the cane growers. The problem of control is, therefore, practically as wide open for further investigation as it has ever been. At the present time it seems that

reasonably practicable and economical control measures must be found in the near future if the cane-growing industry is to be preserved in the United States.

A brief survey of the developmental stages of the insect and a brief description of its work may aid in giving a clear understanding of the nature of the problem and the difficulties involved. The eggs are laid in batches numbering up to 50 or more on either the upper or lower surfaces of the leaves and usually upon leaves that are quite mature and at a point where the surface approaches a horizontal position. These eggs hatch usually in from 5 to 9 days. They are subject to a high degree of parasitization by *Trichogramma minutum*, especially after corn has become mature and the parasites transfer their attention from the eggs of the corn earworm and the tomato horn-worm to the eggs of the cane borer.

Upon hatching the young larvae make their way as quickly as possible to the leaf roll of the growing corn, cane or other host plant. It appears that it is necessary for these larvae to find this tender leaf tissue to enable them to develop through the second instar, but after that time they are capable of boring into the stalk. The work of the young larvae in the leaf roll becomes very conspicuous as the leaves develop, showing as minute perforations extending usually entirely through the tissue of the leaf and arranged frequently in a row of 4 or more holes arranged in a straight line and at uniform intervals apart, across the blade of the leaf. This characteristic feeding work of first stage larvae may be found upon both corn and cane and marks plainly the stalks where the initial infestation occurs. The larvae usually spend at least a week thus feeding within the shelter of the leaf roll. As they become larger they gradually work their way down the stalk making usually more than one burrow during the period of development from third to fifth instars. The full-grown larvae occur usually in a portion of the stalk that is quite mature. Their work in this stage is naturally most extensive and may extend into two joints of the corn or cane. When ready to pupate the larva prepares the exit hole for the moth, closes this with a wad of coarse frass, then retires downward usually into its burrow where it forms a slightly specialized cell for pupation. The pupal stage is passed in about a week and the moth emerges at night, or during dusk.

The extreme effect of borer damage to cane may extend to complete destruction of the crop. This is uncommon but occurred in a number of localities in 1925. Such fields were not cut and must have sheltered large numbers of full-grown larvae through the hibernation period.

There is a definite difficulty in applying insecticides to a crop like full-grown sugarcane. Such treatment is called for, as a rule, only after the first of August at which time cane is usually at least 6 ft. high. No ground machinery or even hand guns can be used readily in such a crop. The stalks commonly overlap across the rows, and it is impossible to get machinery through such a field.

However, during recent years, the development of airplane dusting for boll weevil control has provided a method for distributing dust poisons on crops which cannot be treated otherwise. The initial effort to control the cane borer by means of calcium arsenate dusting from airplanes was undertaken at the Louisiana Experiment Station in September, 1925. A very ideal distribution of dust was secured; but in spite of this the borers were not controlled. It appeared that the larvae would push the calcium arsenate particles aside before beginning to feed and less than 20% of the larvae were killed by this method of treatment. A very limited test of sodium fluosilicate dusted from the airplane in comparison with the calcium arsenate application gave surprisingly good control of the borer stages. There was some burning of foliage, but this was not severe enough to be considered a serious matter. These initial tests in 1925 furnished the clue which has been followed by far more extensive work in 1926.

At the request of sugarcane growers the Louisiana Legislature in July 1926, appropriated $25,000.00 per annum for two years for sugarcane investigational work. Slightly more than half of this amount has been set aside for entomological studies. This made possible a substantial extension in the program of work which had already been started on the sugarcane borer.

Early in the season it became apparent that the first generation of the sugarcane borer developed more abundantly in early planted corn than in the cane fields. In fact, the first two generations of the borer appear to be concentrated on corn to an important degree and many planters undertook to cut out the infested corn stalks and feed them green to farm animals, or otherwise dispose of them so as to prevent the emergence of the moths therefrom. It was found possible to train an ordinary field hand in a few minutes so that he could remove more than 90% of the borer stages from a corn field and this, as a rule, necessitated the cutting of only between 10 and 20% of the stalks of corn. An examination of corn fields showed that the borer infestation was not distributed at all uniformly through the various fields, but that many fields were practically uninfested and might be allowed to mature their

corn while certain fields had apparently been in a particularly attractive stage just at the time that the moths were flying and had served to attract and to concentrate the egg laying for that generation in that particular locality.

The study of borer control by the destruction of the infested corn stalks was supplemented by insecticidal control tests beginning early in the season and continuing to about the middle of October. The first work was done on corn as borer stages could be found there far more readily than on cane. A Root hand dust gun served for the distribution of the poison. Careful records were kept upon the burning of foliage and upon toxicity to the borer stages. In many of these tests on corn from 55 to 75% of borer larvae of all sizes were killed. The natural mortality among larvae more than half grown on untreated cane averages only 1 or 2% and is, therefore, practically negligible. It was found also that from 5 to 9% of pupae were killed in this treatment of infested corn. Corn foliage is much more susceptible to burning than cane foliage and served therefore as a convenient index in comparing the burning effect of the various samples of sodium fluosilicate and other materials tested.

A casual examination of the normal stalk and top of sugarcane shows that there is only a small area of leaf per stalk that is in a horizontal position or sloping toward the stalk. The structure of the leaf is favorable however to conducting dust, dew or rains down the channel, along the mid-rib of the leaf, to the stalk. This is a very important factor in our consideration of this problem, and explains in a large degree the success that has been obtained in this insecticidal work.

It has been found that with the sugarcane borer the percentage of borer control varies quite directly in proportion to the percentage of water soluble fluorine in the material used. In normal sodium fluosilicate approximately all of the fluorine content (60%) is ultimately water soluble. In calcium fluosilicate the water soluble element is only about 4%. Accordingly, calcium fluosilicate is inactive and does not burn foliage or kill the borers while the sodium fluosilicate is decidedly active and does destroy a large percentage of larvae and may also, under certain conditions, cause some burning of foliage. It is apparent that the principle involved in this use of sodium fluosilicate depends on its water solubility primarily, and this solution washing downward bathes the stalk of the plant and may even extend into the burrows of the borers and cause their death there without having the borer come to the exterior to feed.

There are many problems connected with the insecticidal use of sodium fluosilicate as a dust for cane borer control at least. These problems and possibilities cannot be discussed at this time.

The operation in airplane dusting is essentially similar to that involved in cotton dusting for boll weevil control. The dust hopper of the airplane holds from 500 to 700 pounds of such a material as sodium fluosilicate. The material used in 1926 was shipped in barrels holding 275 pounds net, therefore, two barrels gave conveniently an airplane load of 550 pounds. In part of the tests it was deemed advisable to mix 10% of hydrated lime with the sodium fluosilicate to reduce the danger of burning to the cane foliage. This mixture was accomplished by pouring the required materials together slowly into two barrels and the mixture was made fairly uniform as these were emptied into the hopper of the plane while the action of the agitator in the hopper and of the air blast discharging the dust cloud gave as complete and uniform a mixture of the materials as they reached the cane foliage as could have been secured with more elaborate advance mixing.

In flying over the cane field the pilot would lay down his first swath along the edge of the field away from the direction of the air movement so that he was not obliged to fly back and forth in his own dust cloud. Succeeding swaths were laid down at intervals of about 100 ft. with sodium fluosilicate. This covers about 17 rows of sugarcane on the average. The swath-width with sodium fluosilicate of the lightest density now available is less than half the average width that is usual with calcium arsenate. This means that the airplane must do twice as much flying to cover the same area of cane with fluosilicate as for cotton when using calcium arsenate. The vertical smooth leaves of sugarcane do not hold sufficient poison to show the pilot plainly where his last swath was laid down and ditch lines, roadways, etc.. help largely in guiding him to his proper position in the field. It is probable that flag markers set in advance at proper swath widths will be used in future experimental work of this kind. The airplane passes over the cane at a height of usually 10 or 15 ft. above the tops. The distribution of dust from an airplane is so uniform that a heavier poundage per acre is required than was found necessary with hand gun work where the outlet passed relatively much closer to the tops of the plants. Thus approximately 10 pounds per acre on corn had given a very satisfactory degree of control of the borer, but from 15 to 20 pounds per acre were required with the airplane to give about the same percentage of control on cane. The average application given covered approximately 25 acres of cane

with a 500 pound load of poison. This meant that the planes flew approximately 2 miles over cane while discharging this load. The actual dusting time involved was less than 2 minutes per load in the treatment of 25 acres of cane. This is about one-half the acreage-covering rate secured on cotton with calcium arsenate.

In this Louisiana dusting work on cane in 1926 the expense involved has been shared through a cooperative arrangement whereby the planter has borne the expense for the poison used while the Experiment Station has borne part of the application expense and the balance has been carried by the Huff Daland Dusters, Inc., who have been exceedingly helpful in carrying through this initial series of experiments. In this way more than 1300 acres of cane were dusted at the Louisiana Sugar Experiment Station and on the plantations of A. Wilbert Sons & Company at Plaquemine, Louisiana.

The borer infestation of 1926 has been unusually light in cane. Under these conditions the dusting work was begun the last of September and only a single application was made. It is entirely possible that the work of another season with much heavier infestation may be expected to show quite different results. At the present time, however, it appears that the degree of control secured from a single application of sodium fluosilicate as now available has given a very encouraging degree of borer control for initial work. It seems reasonable to expect that a higher degree of control may be possible in the future with improved materials and with a fuller knowledge of the conditions essential to most effective work.

To learn the final results of this work it has been necessary to cut up and examine carefully at the end of the season nearly 3500 entire stalks of cane taken as representative samples from dusted and undusted areas. Examinations made in the field before the dusting had shown the percentage of stalks showing borer burrows of any type. The splitting up of stalks showed the various sizes of larvae killed or still living, and all other stages found were also recorded. The final examinations made about six weeks after the poison application shows the difference in the percentage of joints infested on dusted as compared with undusted areas, after the next generation had time to develop.

Typical records showing these results are given in the following table:

RESULTS OF AIRPLANE DUSTING WITH SODIUM FLUOSILICATE

Variety	Treatment	No. Canes	Infestation		Borers per 100 canes
			% Joints	% Canes	
Purple.....	Dusted	799	12.63	78.9	45.5
Purple.....	Check	597	23.79	95.1	78.2
Striped.....	Dusted	593	10.2	70.1	36.9
Striped.....	Check	197	27.4	98.0	66.0
D-74.....	Dusted	682	13.2	63.1	38.6
D-74.....	Check	200	28.7	91.5	76.5
D-95.....	Dusted	190	13.3	70.0	60.0
D-95.....	Check	200	32.6	98.4	75.0
Totals.....	Dusted	2264	12.08	70.84	41.2
	Check	1194	30.13	95.78	80.1

It will be seen that the average percentage of infested joints in dusted areas is only 2/5ths of that in the undusted areas, and that the number of borer stages found alive per 100 stalks was cut in half by the dust application.

The practicability of applying an insecticidal dust to a crop like sugarcane has been fully demonstrated at the Louisiana Experiment Station and the planters of Louisiana and of other countries as well may find in this method of treatment a valuable help in controlling various insect enemies of cane and other crops for which no method of treatment has been available heretofore.

MR. R. B. ARNOLD: What was the cost per acre of the dust and its application?

MR. W. E. HINDS: The amount of dust used was fifteen to twenty pounds per acre. We found it was necessary to nearly double the amount we used with hand guns because the airplane distributes evenly over all the spaces and does not concentrate it upon the heart of the plant. The cost for material ranged from eight to ten cents a pound. The cost for experimental work is not, of course, any gauge of what could be done in commercial work. Our actual cost was distributed among the growers who paid for the poison, the experiment station which bore part of the cost of the application, and the Huff-Daland Dusters Inc., who bore the balance of it. We haven't really figured up and wouldn't want to announce any cost per acre. This was strictly experimental work. I think that it would not exceed more than three dollars as an average proposition.

PRESIDENT ARTHUR GIBSON: I would like to ask what he would regard as the best time of the year for applying this.

MR. W. E. HINDS: That would depend absolutely upon the condition of borer infestation. As a rule we would not have conditions calling for it before the middle of August; from then until the end of September would be about the normal season. We expect from what we have done this year that it will take about two applications under heavier infestation conditions.

We have had some burning, but the burning has not been very serious; it has not interfered with the growth of the plant or the value of that cane for planting the following season or the yield so far as yield is concerned.

MR. R. B. ARNOLD: Would it affect the flavor of the juice?

MR. W. E. HINDS: If you were to drink the juice as it comes from the presses, there might be a trace of sodium fluosilicate found in it, but in the process of crystallizing the sugar that is eliminated and you need not fear drinking your coffee or tea with sugar.

MR. R. B. ARNOLD: How about its use for syrup?

MR. W. E. HINDS: The amount present would be so slight it is questionable whether you would more than detect a trace. Only the main stalk goes into the crushing machine.

PRESIDENT ARTHUR GIBSON: The next paper is by W. E. Britton.

ORGANIZATION OF A CO-OPERATIVE CAMPAIGN AGAINST THE ASIATIC BEETLE

By W. E. BRITTON, *State Entomologist, New Haven, Conn.*

ABSTRACT

Injury to lawns in New Haven by the Asiatic Beetle, *Anomala orientalis*, became so prominent late in 1925 that official control seemed warranted. Federal experts advised a co-operative study of the insect and treatment of the soil to kill the grubs. No special funds were available, though State funds could be used and replaced later by a deficiency appropriation. Property owners offered to contribute, and a local civic association appointed a committee to solicit and collect funds. Over $4,500.00 were obtained. The Association also obtained an appropriation of $2.500.00 from the City of New Haven. Congress appropriated $5,000.00 for the work. The area was quarantined. A place was leased for headquarters and an insectary built. Life history studies were made under the supervision of R. B. Friend, and quarantine regulations enforced, and scouting and soil treatment work conducted under J. P. Johnson. Altogether 19 tons of emulsion were purchased and used. Though not all bills have yet been paid, the amount expended for payroll is $7,884.59, and $4,244.21 has been paid for emulsion. A total of $17,089.12 has been expended, apportioned from the four appropriations as follows: Civic Association, $4,086.71; City of New Haven, $2,471.83; Federal appropriation $5,000.00; State funds, $5,530.58.

Late in the season of 1925, the injury caused by the Asiatic beetle, *Anomala orientalis*, to lawns in the western part of New Haven seemed

sufficiently prominent to warrant official action in controlling the pest. Many property owners had asked for information about the insect and for advice about restoring their lawns. Experts from the Japanese Beetle Laboratory of the Bureau of Entomology visited New Haven and, after a brief survey of the situation, recommended that life history studies be made; that the soil be treated with emulsion to kill the grubs; that it should be done co-operatively, and estimated the cost at $25,000.00.

There were no specific funds available for the purpose. To be sure, our State appropriation had not all been expended, and it was not illegal to use it, but the projects and the budget showed that it was all needed for the work already under way.

Some of the property owners expressed a willingness to contribute toward a fund to help, as the work would directly benefit them. A local organization known as the Edgewood Civic Association seemed the logical agency to take the initiative. Consequently, the matter was brought before the Executive Board, and the State Entomologist accepted the invitation to give an illustrated lecture on the subject at the annual meeting of the Association, November 18, 1925. A resolution was passed authorizing the president to appoint a committee to solicit and collect subscriptions. This committee was appointed and outlined its campaign, but before the canvass took place, a public meeting was held in a local junior high school and illustrated addresses were given by the State Entomologist and Mr. Loren B. Smith of the Japanese Beetle Laboratory, Riverton, N. J. A state quarantine was established. The canvass was made in April, and leaflets giving information regarding the insect and the quarantine regulations were distributed to every family in the quarantined area. The money and pledges obtained amounted to over $4,500.00.

As this insect was not known to be present in any other portion of the city of New Haven, and as the treatment would in some measure protect other parts of the city, the Edgewood Civic Association caused a petition to be introduced before the Board of Aldermen asking for an appropriation of $2,500.00. After taking the usual course, including a public hearing duly advertised, the petition passed the Board of Aldermen, and finally the Board of Finance, was signed by the Mayor and the money became available.

Congress was asked to add $15,000.00 to the budget for Japanese Beetle work, the increase to be used against the Asiatic beetle. Congress

responded by appropriating $5,000.00 for the purpose, available July 1, 1926.

We regarded the situation as an emergency, and placed the facts before the members of the State Board of Finance, who approved our plan of going ahead with the work and expending a part of the State appropriation, this amount to be replaced later by a deficiency appropriation.

A stable and yard at 132 West Elm Street were leased as headquarters, and a temporary insectary was built. The life history work was assigned to R. B. Friend, with Paul A. Davis as assistant. J. P. Johnson was engaged to take charge of the quarantine enforcement, scouting and soil treatment work, and he was assisted by Charles E. Brown and about twenty young men, mostly high school boys, as this seemed the best kind of help quickly available.

Bills were paid from each appropriation on duly accredited vouchers. All supervision, permanent apparatus, equipment and supplies, such as hose, nozzles, tools, rental, etc., were paid from the State appropriation. The Federal funds were paid for labor and equipment. Most of the City funds went for labor, and a small portion for emulsion. In general the contributed funds were expended for the purchase of emulsion.

In all, 19 tons of emulsion were used, and bills amounting to $1,500.00 still remain to be paid. The amount paid for emulsion was $4,244.21. The entire payroll amounted to $7,884.59. The total amount expended for Asiatic beetle work was $17,089.12, apportioned from the four appropriations as follows:

SOURCES OF FUNDS

	Appropriation	Expended
Edgewood Civic Association	(Indefinite)	$4,086.71
City of New Haven	$2500	2,471.83
Federal Bureau of Entomology	5000	5,000.00
State of Connecticut	(Indefinite)	5,530.58
Total		$17,089.12

PRESIDENT ARTHUR GIBSON: Mr. R. B. Friend will now present his paper.

THE ASIATIC BEETLE (*ANOMALA ORIENTALIS* WATERHOUSE)

By R. B. FRIEND

ABSTRACT

The Asiatic beetle (*Anomala orientalis* Waterhouse) in Connecticut has usually one generation a year, but in a small percentage of cases it takes two years to complete the life cycle. Hibernation takes place as a rule during the third instar. The larvae pupate during June and July, and adults occur during July and August. If the larvae hibernate during the first instar, they do not complete development the following season but go thru as larvae and pupate a year later. This insect seriously injures lawns by eating the grass roots during the larval stages. The injury is particularly noticeable during September. The adults are not pests of any importance.

The Asiatic beetle is an insect rather recently imported into the United States, and it may become a serious pest if it continues to spread and multiply. The life history notes here given are the results of observations in Connecticut during 1926.

The adult beetles are of the typical Scarabeid shape and 8–12 mm. in length. The color varies from entirely straw-colored to entirely black, but typically the beetle is straw-colored with black markings. The thorax may be entirely black except for a straw-colored margin, or there may be a light line medially which divides the thorax into two black areas. The elytra are usually straw-colored with one or two black U-shaped bands and a dark spot at the inner basal angle of each elytron. The ventral side of the insect is light or dark, corresponding to the predominating color of the dorsum. The females are usually larger and lighter colored than the males, but black females occur. The sexes may be determined by the relative length of the tibial spur on the prothoracic legs, this being longer and narrower in the female.

The egg is small, white, and ovoid when first laid. After being in the soil a short time, it swells to a spherical shape and a diameter of about 1 mm. The fully grown larva is a little over 2 cm. in length and may be distinguished from other Scarabeid larvae by the number and arrangement of the two median rows of short pointed spines on the ventrum of the anal segment. There are 12–14 spines in each row, and the rows diverge slightly craniad. The arrangement of the more lateral, larger hooked spines is also characteristic.

This is a grassland insect, spending its larval life in turf, mainly in lawns, where it occurs in numbers up to 1000 per square yard in spots. The infestations are not uniform over any large area and usually not over any one entire lawn. The larvae feed on grass roots and dead organic matter close to the surface of the soil, and in September the

grass is frequently killed. The adult is not injurious to anything except flowers in Connecticut.

The great majority of larvae winter in the last instar at a depth of from ten to fifteen inches in the soil. They come to the surface to feed the last of April and first of May, and continue feeding for about six weeks. The injury to grass is not superficially apparent at this time. If a dry spell of weather occurs, the larvae will go more deeply into the soil. About the middle of June they go into the prepupal stage at a depth of three to nine inches below the surface. A large subdermal deposition of fat gives the prepupa a yellowish-white appearance, and the legs are folded and useless. After seven days they pupate, and this stage lasts fifteen days. We have found pupae from June 17th to August 19th in New Haven, but the maximum number were found the last week in June and the first week in July. The first adult was found in the field June 25th, and the last August 28th, the maximum number being picked up the first three weeks in July.

The adults remain in the ground a varying length of time after emergence from the pupal stage, but we have records of oviposition one day after emergence. A considerable part of the adult life is spent in the ground. Most of the flying takes place between 7:30 and 10:00 a. m., and between 1:30 and 4:30 p. m., according to the records of the scouting crew, but there is some evidence of night flying and attraction to lights at night. The flight is rather swift and of short duration, usually but a few feet, although occasionally a long flight is observed. As an indication of the extent of movement above ground, it is illuminating to note that twelve scouts picked up only 2402 beetles in two months, and there were a large number of infested lawns any one of which contained several times that number of larvae. The adults feed on flowers, eating the petals and the center of the blossom, and in the insectary we feed them pieces of ripe apple. There is a decided preference for light-colored flowers, and roses, hollyhocks, phlox, and dahlias are preferred in the order given. In no case is the feeding very extensive, and it may be moisture that is sought, for the beetles burrow into a wet sponge more eagerly than into a piece of apple.

The eggs are laid singly in the ground at a depth of from three to nine inches. Oviposition occurs during both night and day, and a female will lay a few eggs at frequent intervals for several days. The largest number of eggs we secured from one female was thirty-two, laid over a period of seven days. Another female laid seventeen eggs over a period of twelve days. Eggs were found in the field from July 19th to September 10th.

The period of incubation averages twenty-eight days, but this varied from ten to forty-one days in the insectary. Moisture is necessary for development of the egg, and exposure to air-dry soil for ten days is usually fatal. Under natural conditions in New Haven the soil does not get as dry as this.

Upon hatching, the young larvae make their way up to a position close to the surface of the soil and there feed on roots and organic matter. We found the first larvae in the field August 12th. Feeding continues until freezing weather, when the nearly full-grown larvae go down more deeply to hibernate. During the feeding period they molt at least twice in the majority of cases, but some individuals hibernate before the first molt. This last season the downward migration began about October 10th, and diggings made the first ten days in November indicated most of the larvae were at a depth of six inches or more at this time. Injury to the grass is not apparent until September, probably not until the second instar is well under way. Where the infestation is heavy, the dead turf is easily rolled back, disclosing the larvae in the upper inch.

There is usually one generation a year, but larvae which hibernate in the first instar go through the following season as larvae, hibernating the second winter in the third instar. These individuals take two seasons to complete the life cycle.

The most important natural enemies we have observed are birds and ants, and many larvae are destroyed by both these agents. We hope to establish parasites in the future.

This beetle is reported as common on all the islands of Japan, and it throve in Hawaii until controlled by an introduced parasite. This latitude range extends about as far north as northern United States and much further south than Florida and Texas. In New Haven we have one generation a year with the possibility of a two-year cycle in a few cases. In Hawaii there are two generations a year. To date, all our infestations have been on grassland, and the only important crop injury of which there is record is to sugar cane in Hawaii. The injury which this insect may do is problematical.

MR. W. A. HOOKER: I would like to ask Dr. Britton in regard to the extent of the infestation by this pest. It is my understanding that the infestations in New York state are separate introductions.

MR. W. E. BRITTON: It has been discovered on Long Island, also in Westchester County, New York. We don't know, of course, how it got

there, but there are a large number of nurseries there, and also private individuals might have imported it before nursery stock was kept out by the Federal quarantine. It may have been introduced into those places at the same time, or even before, it was introduced into Connecticut, as far as we know. It must have been in this one place on Long Island as long as it has been anywhere in Connecticut.

PRESIDENT ARTHUR GIBSON: The next is a paper by J. L. King, H. W. Allen and H. C. Hallock.

Mr. Allen read the paper.

THE PRESENT STATUS OF THE WORK ON THE PARASITES OF *POPILLIA JAPONICA* NEWMAN.[1]

By J. L. KING, H. W. ALLEN and H. C. HALLOCK, *U. S. Dept. of Agriculture, Bureau of Entomology*[2]

ABSTRACT

This paper is a summary of the parasite introduction work since January 1, 1925, at the Japanese Beetle Laboratory, Riverton, N. J.

"The important points discussed are the spread of the parasite *Centeter cinerea* Ald., in New Jersey and Pennsylvania. The successful establishment of *Tiphia popilliavora* Roh. from a very small liberation is noted. The work on *Prosena siberita* Fab., *Dexia ventralis* Ald., and *Tiphia vernalis* Roh., and several other parasites is also discussed. There are some concluding remarks on some of the problems connected with parasite introduction work.

This paper deals with the progress of the parasite work at the Japanese Beetle Laboratory from the fall of 1924 to the fall of 1926 and is the third of a series published in this Journal[3]

The establishment of a natural balance, which is the fundamental idea

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[1]Contribution No. 19, U. S. Department of Agriculture, Japanese Beetle Laboratory, Riverton, New Jersey.

[2]In presenting a paper of this nature which is necessarily based on the efforts of several workers, it is with sincere appreciation of their work that the following acknowledgments are made. Messrs. J. B. Cronin and L. B. Parker were formerly connected with the receiving station and contributed, with the joint authors, to the results presented in this paper. The writers also wish to acknowledge the careful work of the men in the foreign field and its vital importance in contributing to success at the point of colonization. Special acknowledgment for the collection of foreign parasite material is due Mr. Curtis P. Clausen, in charge of the foreign phase of this project. Mr. Clausen, who is located in India, is responsible for all the Indian material, and his assistants Mr. H. A. Jaynes for all material from China and Mr. T. R. Gardner for material from Japan and Korea.

[3]Other papers are: (1) A preliminary report on the foreign parasites of Popillia japonica. Clausen, Curtis P., and King, J.L., JOUR. ECON. ENT., Vol. 17, pp. 76–79, 1924. (2) A report on certain parasites of *Popillia japonica* Newm. King, J. L., and Hallock, Harold C., JOUR. ECON. ENT., Vol. 18, pp. 351–356, 1925.

behind any biological control, is at best a slow and tedious process. The difficulties encountered are numerqus and we believe that in the case of soil-inhabiting insects, as Popillia and certain of its parasites, these difficulties are somewhat above the average. However, in spite of this, the recovery of two species of Tiphia during the past season has shown that the difficulties may yet be overcome. Studies of the habits and improvement of insectary methods as used with the more difficult species have yielded results encouraging enough to lead us to believe that in the future even these species may be added to our fauna.

Discussion of the Tachinid Parasites

Centeter cinerea Ald. Although this Tachinid was established in 1923, a further shipment of approximately 50,000 host beetles was received at Riverton in the fall of 1924. Approximately forty per cent of this lot contained Centeter puparia. This consignment was divided into two equal lots. One of these lots was wintered under the soil out-doors and the other was wintered in a cool cellar. Out-door hibernation proved the better since it gave 71 per cent of the total emergence. The 1925 liberation was made in the 1924 colony center at Torresdale, Pa., and consisted of 2,180 unmated adults.

This species is now firmly established in the Japanese beetle area. The known area of distribution has increased to 60 square miles and now extends into Pennsylvania.

Ochromeigenia ormioides Town. Additional shipments of this nocturnal Tachinid were received from Japan during the summers of 1925 and 1926. The methods of shipment and insectary manipulation described in an earlier paper were found satisfactory and are still used. Unmated adults, including 228 in 1925 and 743 in 1926, were released at the 1924 colonization point near Riverton, N. J., in order to strengthen any possible colony which may have started there from previous liberations.

In recovery experiments no Ochromeigenia were obtained from approximately 23,000 beetles, collected at the colonization point, during the summer of 1926. Although the failure to recover up to the present time has been disappointing, further attempts to colonize will be made.

Prosena siberita Fab. Additional shipments of *Prosena siberita* were made during 1925 and 1926. The 1925 shipment consisted of 25,000 Japanese beetle grubs from which 1,693 adults were obtained. The same number of grubs was received in 1926 and yielded 1,287 parasites. The method of shipment, which was the same as that used in 1924, has given, on the whole, very satisfactory results. The methods of in-

sectary manipulation of this parasite have also been practically the same as for 1924.

The 1925 shipment was colonized at Holmesburg, Pa., and the 1926 shipment was released at the center of the original colony at Moorestown, N. J. Each location was selected because it combined a number of conditions supposedly favorable to the fly, such as an abundance of late maturing grubs of the host and the proximity of mesophytic woodland fringe with an abundance of flowers and luxuriant vegetation frequented by large numbers of native Tachinidae and therefore probably a favorable habitat for the introduced species. The Moorestown colony has now received liberations during 3 seasons. Repeated liberations have been made at this colony center, since there has been no reason to question its suitability to the parasite and since it has been thought that new liberations would serve to strengthen a young struggling colony and increase its chances for establishment. To date 7,560 parasites have been liberated, of which slightly more than 1,600 were released in the Pennsylvania colony and the remainder in New Jersey.

It is as yet somewhat too early to state definitely whether the species is established. Although there have been some favorable indications, the attempt to colonize this species has proved rather disappointing to date, and the parasite, if present, occurs in such small numbers that it has been impossible to measure its presence quantitatively by any of our recovery work. In 1925 one unfertilized female was taken 5 miles from the point of liberation and in 1926 a single fertile female was recovered a few hundred feet from the colony center. Both recoveries have been regarded as individuals from the liberations of the current year, but it is possible that they were from an established colony.

This fly is a polyphagous species naturally parasitic on the Japanese beetle and widely distributed in eastern Asia. There appears to be no reason why it should not become established in eastern North America. However, several years' work with the species has emphasized the importance of several of its characteristics which increase the difficulty of successful colonization. One of these is what might be termed the pronounced dispersive tendency in a colony liberated in the field. The adults are strong fliers and disappear from view into space or the high trees over-head, almost instantaneously at the time of liberation.

It was found during the summer of 1926 that adults which do not mate freely in confinement would do so quite readily in large out-door cages, covered with black mosquito netting. By releasing mated

females we now hope to counteract to some degree any disadvantage arising from the dispersive tendency described above.

Dexia ventralis Ald. The first consignment of this Korean Dexiid was received at the laboratory in July, 1925. This shipment consisted of 850 Popillia grubs which had been inoculated with first-stage Dexia larvae. During the season 28 adults emerged from this lot and gravid females were obtained. Maggots obtained from these females were allowed to parasitize Popillia grubs but failed to mature.

The first 1926 shipment consisted of 4,116 host grubs containing second generation Dexia maggots and was received at Riverton in July. Upon arrival most of the parasites had left the host and were in the puparial or larval stage. These were placed in soil for emergence. The total emergence was 1,501, of which 1,352 were released near Haddonfield, N. J. Mating was obtained in captivity and gravid females also were found at the point of liberation. *Popillia japonica* grubs were inoculated with first-stage Dexia larvae, which were obtained from the gravid females, and adults emerged from these in September.

During the early fall of 1926 three consignments of the third-generation Dexia parasites contained in 5,684 host grubs were received at the laboratory. From these consignments 176 adults emerged and were liberated near Haddonfield. The adults of *Dexia ventralis* do not spread rapidly from the liberation point as is the case with Prosena. At the Haddonfield colony for several days following liberation, especially during the evenings, many adults were observed resting upon the grass, or darting about, flying but a short distance before alighting again.

Discussion of the Scoliid Parasites

Tiphia popilliavora Roh. During the past two years only shipments of adults have been made. In 1925, from a shipment of 1,030 females arriving from Koiwai, Japan, 43 active females were obtained at Riverton and liberated at once. In 1926, from 1,219 females shipped from the same locality, 22 active females were obtained. The 22 adults of the 1926 shipment were used in propagation work from which ovipositions on 331 Japanese beetle grubs were obtained. The cocoons from this lot have been placed in storage.

Four separate colonizations of this species have been made within four miles of the laboratory at Riverton. This parasite was recovered for the first time during the past season and appears to be definitely established, though as yet present in rather limited numbers over a small area. Numerous males were encountered near the Riverton

laboratory on the flowers of wild carrot in August, and later, parasitized Japanese beetle grubs were recovered at the same locality in considerable numbers over an area about 300 yards in diameter. The present colony, which must number at least some thousands of individuals, has very likely sprung from a very few females released in 1922.

Tiphia vernalis Roh. The first shipment of this Korean *Tiphia* reached Riverton late in August, 1924. From this lot 116 adults, of which only 30 were females, emerged, and 30 adults, of which 17 were females, were released near Moorestown, N. J., in early May, 1925. A second consignment of 5,965 cocoons reached the laboratory during the fall of 1925. The emergence from these during the spring of 1926 was 275 adults. The reared females were mated and oviposited readily upon *Popillia japonica* grubs in confinement.

Shipments of adult *Tiphia vernalis*, first made during the spring of 1926, have proved more promising than shipments of cocoons. Two lots, containing 2,790 field-collected females, were shipped from Korea. When they reached Riverton 411 female Tiphia were still living. The females were used in propagation work from which 4,301 parasitized grubs were obtained. The parasitized grubs were liberated at the 1925 *Tiphia vernalis* colonization point. Each grub bearing a Tiphia egg was placed just under the sod. The liberated material was scattered over several acres. In October, 1926, this plot was examined. Several cocoons were found about 3 inches below the surface, all of which contained larvae that were in excellent condition. It is hoped that these cocoons formed under normal conditions will give rise to a colony which will be sufficiently strong to insure the establishment of the species.

During the season of 1926 *Tiphia vernalis* was also tried on *Anomala orientalis* grubs in confinement. This Tiphia accepted the Anomala grubs readily and cocoons were obtained from the ovipositions upon the host.

Tiphia No. 1851. This species[4] which occurs in considerable numbers in sandy country and under subtropical conditions at Miho, Japan, was first received at Riverton in November, 1925. This first shipment consisted of 1,030 insectary reared cocoons which arrived from Japan in excellent condition. During the present season an adult shipment has been tried, 1,000 females being sent over in early October. In this lot 111 arrived alive.

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[4]Among the species of Tiphia being imported are certain undescribed or undetermined species which have been given insectary numbers, to which reference will be made at the time of publication of their authoritative names and descriptions.

Two methods of hibernation were tested with the 1925 shipment of cocoons. The first lot was layered between sphagnum and buried in soil outdoors, and the second allowed to remain in the original containers in a cool cellar. The better results were obtained in the lot wintered over in the cool cellar, repacked in the early spring and kept under rather dry conditions until emergence. From the 1925 shipment, 325 adults emerged during July, 1926, and from this lot 90 mated females were obtained, which oviposited readily upon Japanese beetle grubs in confinement. The first liberation of 72 mated females was made in mid-July, a time when the greater part of the Japanese beetle infestation had passed over into the unsuitable pupal and adult stage. A location was found at Merchantville, N. J., however, in which third-instar grubs were still abundant, and other conditions apparently quite favorable for the colonization of adult Tiphia.

Examination of Japanese beetle grubs from the liberation area was made daily from July 19 to 30. Altogether 605 grubs were examined and seven were taken bearing the eggs of this species. The discovery of the fact that this species will attack Japanese beetle grubs in the field is highly encouraging, for although it has been reared in large numbers in the insectary upon this host, it is known in Japan only as a parasite of a species of *Anomala* and does not occur abundantly there in Popillia infested territory.

This parasite has a second generation at Miho, Japan, with adults appearing in September, but our insectary reared material at Riverton during the season of 1926 has passed through but one generation, and no evidence of a second generation has been discovered at the colonization point. This is not an unexpected development, since the laboratory is located at a considerably colder latitude than the native home of this species in Japan.

The adult shipment of 1926 arrived in late October, at the close of the season at Riverton and too late to risk liberation of adults, particularly of a subtropical species. Consequently these females were employed in propagation work, by which a total of 448 parasitized grubs were obtained. The cocoons from these will be wintered over and used during the coming season.

Tiphia No. 2049. Very large shipments of a fall-emerging species of Tiphia, parasitic on species of Popillia and shipped from Shillong, Assam, India, have been received since the early winter of 1925. All have consisted of field-collected cocoons, shipped in small packages by parcel post. Altogether 19,560 cocoons have been received at Riverton.

Unfortunately, owing to the long time spent enroute, a period which averages about 60 days, and probably also the passage through areas of widely varying climate, the vitality of the parasites is much reduced by the time they have reached their destination. Adults failed to emerge at Riverton this fall and the species has passed into its second winter in the cocoon stage. Owing to the presence of a small number of Rhipiphorid secondary parasites and a small number of Chalcids, these cocoons have been handled with great care, being kept in tight containers within a specially constructed cage.

Tiphia No. 114. Adults of this species were first shipped from China in 1926. From 5 consignments, 118 living females were received at the Riverton laboratory during May, 1926. These Tiphia were handled in the same manner as *Tiphia vernalis*, and a small colony of 89 parasitized grubs was placed at the same locality as *Tiphia vernalis*, near Moorestown, N. J.

Tiphia No. 2036. Another Indian species of Tiphia emerging in the spring and parasitic upon species of Popillia was first received at Riverton in the fall of 1925. No adults have as yet emerged at this station. Approximately 2,300 cocoons, most of which were reared in India, and the remainder field-collected, are in winter storage at Riverton.

Campsomeris annulata Fab. Work was continued on this Scoliid parasite during 1925 and 1926. Sixteen consignments of adult females of *Campsomeris annulata* were received at Riverton during 1925, and 2,162 field-collected females were liberated near Moorestown, N. J. During the same period 95 reared adults which had emerged from the 1,198 cocoons received during the 1925 season were liberated at the same locality. Eleven shipments of adults were received in 1926 and 1,945 field collected females of Campsomeris were liberated at the same locality. Additional Campsomeris from the 1926 shipments, to the number of 336, were used in laboratory experiments, by which it was found that Campsomeris would occasionally oviposit on *Popillia japonica* grubs, but not readily.

Some Problems Connected With Parasite Introduction

The problem of perfecting methods of shipment is naturally in the hands of the men stationed in the Orient. The dipterous parasites are being successfully imported as puparia, in the case of those with a long pupal period, and as larvae within the host for species with a short pupal period. The various species of Tiphia are being shipped with a rather variable degree of success in the cocoon and adult stages. The time consumed by shipments enroute is a very important factor affect-

ing successful introduction. Even when the actual mortality is relatively low, our observations indicate that a long period passed in travel is very unfavorable to the parasite and greatly reduces its vitality. Shipments from Japan come through in about 18 days, those from China in about 22 days, while shipments from India have averaged approximately 60 days.

Flies have been liberated, principally in the adult stage, unmated. This method proved entirely satisfactory with Centeter but not entirely so with Prosena. However, it was discovered this season that Prosena will mate readily in large cages covered with black mosquito netting, so that, in the future, liberations of mated females will be made. The Tiphia species have been released largely in the egg stage on the host or as mated adults. The danger of importation of secondary parasites, while not so great as with the parasites of insects which spend a greater part or all of their life about the soil, does exist. Rhipiphorids and Chalcids occur in the cocoons of field-collected Indian Tiphia, and other secondary parasites in the puparia of *Centeter cinerea*. Fortunately, however, the problem of secondary parasitism has been minimized by the extensive insectary rearing of parasites abroad.

It is our conclusion that colonies of powerful flying species, such as Prosena, should be very large, while it would appear that success may come from the liberation of much smaller numbers of Tiphia, the females of which spend much of their life crawling and digging over a rather limited area of ground.

In our insectary work, the matter of hiberantion is one of considerable importance. Nearly all species of Tiphia handled at our insectary winter over rather poorly. On the whole, greater success has been obtained with cocoons kept in a cellar than with those buried out-doors under the soil, although the results vary with the species. It has been noticed that great mortality results from repacking Tiphia cocoons in soil when once removed from the original cell. For this reason, as well as through risk of introducing secondary parasites, it is not feasible to liberate in the cocoon stage. Consequently large numbers of cocoons must be held for varying periods up to a year or more for adult emergence. A number of different setups for holding inactive stages of Tiphia until emergence are being tried, all of which are designed to furnish the requisite degree of moisture, isolation for each cocoon, and something approaching the low variation in temperatures which normally occurs in the soil. Nearly perfect emergence can be obtained with Prosena by simply seeding puparia on moist soil and covering with a

layer of damp sphagnum moss while Ochromeigenia seems to do much better when allowed to force its way up through several inches of soil.

Another puzzling problem is the possible hybridization of nearly related varieties or species introduced into the Japanese beetle area from different localities, and the probable effect of hybridization on the ultimate success of the parasite. *Tiphia popilliavora*, a natural parasite of the Japanese beetle, has now been successfully colonized. A very closely related species or variety has been found in Korea and another in China, which are naturally parasitic on indigenous species of Popillia, but not on *P. japonica* which does not occur on the mainland. The Chinese form is apparently a more abundant parasite in its area of distribution than is *T. popilliavora* in Japan, it is more hardy, and in other ways appears a very valuable species. The question arises, will its introduction result in fusion with the Japanese race, and if so will this be beneficial or not?

The work up to date with the parasites of the Japanese beetle has indicated that each species, even among closely related forms, possesses characteristics to which the method of procedure must be carefully adapted in order to increase the probability of successful establishment.

Adjournment: 5 p. m.

Saturday Morning Session, January 1, 1927, 9:45

President Arthur Gibson, in opening the meeting, expressed hopes that 1927 would be one of great success to every member of the Association.

President Arthur Gibson: The first paper this morning is by J. Peter Johnson.

SOIL TREATMENT AND SCOUTING FOR THE CONTROL OF THE ASIATIC BEETLE

By J. Peter Johnson, *Connecticut Agricultural Experiment Station*

Abstract

Approximately 1400 acres are now under quarantine for the Asiatic beetle, *Anomala orientalis* Waterhouse, in New Haven, Conn. Altogether 2402 beetles were found during the summer scouting season, and 4576 diggings were made in the spring and fall.

The heavy infestation is concentrated in 300 acres, and the larvae injure the lawns severely. Carbon disulphide emulsion was used successfully in controlling them, and during the past year 100 acres were treated.

On April 15, 1926, a quarantine was established in Westville, New Haven, Conn., for preventing the spread of the Asiatic beetle, *Anomala*

orientalis Waterhouse. At the same time preparations were begun for the treatment of the soil to kill the grubs in order to control, and, if possible, eradicate this pest.

The Quarantine

The quarantine included an area of approximately 400 acres and prohibited the shipment of soil, loam, plants with or without soil about the roots, turf or sod trimmings, lawn clippings, ground litter, weeds and manure or compost, which had lain upon the ground, excepting where certification after treatment or inspection was possible.

After the summer scouting was over, the quarantine was revised, effective November 10, 1926, and nearly 1000 acres of new territory were included. There are now approximately 1400 acres under quarantine. At the present time there is no need for a farm products' quarantine.

Diggings

In the spring it was thought necessary to make diggings throughout the quarantine area to determine the nature and extent of the infestation. Altogether 1800 diggings were made, approximately 50 feet apart. The infestation was found to be spotted, and in places there were as many as 1000 grubs in a square yard.

Diggings were resumed in the fall, as the summer scouting work did not give all the information needed for intensive control work. The spring work was duplicated in addition to all areas in which adult beetles were found, and 2776 diggings were made.

During the season 50 or more complaints of possible grub infestations were received from outside of the area. These were examined, and on May 17, 1926, an infestation was found at 437 Savin Avenue, West Haven, and on October 4, 1926, another infestation, one city block in extent, was found on Washington Manor Avenue, West Haven.

Scouting

During the second week in June, information obtained by field diggings indicated that the grubs were approaching the pre-pupal stage. The first pupa in the field was found on June 17, and scouting was begun at this time. The first beetle was found on June 25.

Altogether, 2402 beetles were found during the season; 1132 were recorded on 25 different varieties of plants; 604 on grass, on the ground and in the ground; 147 on the wing, while the others were recorded only as to their location. Beetles were found more prevalent on roses, grass, hollyhocks, phlox, dahlias, beans and corn, named in respect to the number of beetles found on each.

The adult beetle is more readily seen when resting than when flying. It is a rapid flyer and may skim along a few feet above the ground or high in the air.

Beetles were found at night, resting on telegraph poles, on the ground, and as many as eighteen were caught in a half hour flying against the glass and on the sill of a brightly illuminated store window.

The territory surrounding the known infested area was thoroughly scouted, and beetles were found north, south, and east of the quarantine area. The last beetle in the field was found on August 28.

Soil Treatment

The soil treatment was made with emulsified carbon disulphide diluted in water. All of the emulsion was made by a commercial firm in Philadelphia, Pa., according to the formula recommended by the Japanese Beetle Laboratory. It was used at the rate of one quart of emulsion to fifty gallons of water, and three pints of the liquid were applied to one surface square foot. This dose is effective to a depth of nearly three inches, obtaining a grub kill of 98% when applied properly.

In all, 366 properties, totaling 43.5 acres, were treated.[1] Altogether 38,000 pounds of emulsion were used and over 800,000 gallons of water were employed in diluting it. During the spring, seven "Thomas proportioning machines" with a capacity of 600 gallons an hour, and in the fall, four similar machines and another of 1200 gallons, capacity were used in diluting the emulsion.

House hydrants, and, to some extent, fire hydrants, furnished the water supply for the spring treatments. However, much difficulty was encountered with varying water pressure decreasing the efficiency of the work. Therefore, during the summer, fire hose, using fire hydrants as a source of supply, was tested and adopted for fall treatment. This method enabled the machines to work constantly at a maximum flow.

As a whole, the soil treatment has been very effective in reducing the number of grubs throughout the area. The grub injury now apparent in Westville is located on those streets which were not treated, or injured prior to treatment.

A summary of the work done is given in the following table:

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[1]The acreage is the actual surface treated, but the total area including houses, garages, and sidewalks, would be nearer 100 acres.

	Treated		Emulsion used		Water used	No. diggings made
	No. premises	Acres	Lbs.	Tons	gallons	
Spring	147	21	18,500	9¼	400,000	1800
Fall	219	22.5	19,500	9¾	404,377	2776
Total	366	43.5	38,000	19	804,377	4576

PRESIDENT ARTHUR GIBSON: The next paper is by E. Avery Richmond.

A NEW PHOTOTROPIC APPARATUS[1]

By E. AVERY RICHMOND, *Agent, United States Department of Agriculture*

ABSTRACT

An apparatus recently devised for use in connection with certain phototropic experiments on the Japanese beetle, *Popillia japonica* Newm., relative to the value of color and light.

I. INTRODUCTION

Since the appearance of *Popillia japonica* Newm. on American soil the rôle played by light in the life activities of the adult beetle has been only briefly considered by investigators. Apparently the first attempt at investigating this question was stimulated by Uchida's translation of a Japanese text-book by Matsumura, as cited in 1917 by Dickerson and Weiss. According to Matsumura the beetle could be attracted by lights.

Goodwin, 1919, made an effort to put into practice the thought expressed in this translation but, as is doubtlessly well known, his experiments were strikingly negative. In fact, in certain cases, more beetles came to unlighted lanterns. The fact that beetles become inactive after dark, especially when the nights are cool and damp, tends to discount any noticeable response of this sort.

The next investigation resulted in the interpretation of the Weber-Fechner law in relation to the adult by Moore and Cole, 1921. The main thoughts expressed by these authors are taken verbatim from their summary as follows:

1. "Light and a temperature above 23 degrees C. are necessary for the activity of Popillia." 2. "The effect of light, as indicated by the rate of locomotor response, is related to light intensity according to Fechner's expression of Weber's law." It was also stated in their paper that "under ruby light and in the dark, most of the beetles become quiet and show no response to gravity. Occasional individuals, which do not move, show a retarded response. All are roused to activity by

[1]Contribution No. 22, United States Department of Agriculture, Japanese Beetle Laboratory, Riverton, New Jersey.

illumination from any direction while a great increase in the strength of the light causes marked acceleration of movement and flying."

During 1923, F. J. Brinley conducted several experiments in an endeavor to test the effect of colored spray deposits. Precipitated chalk (CaCO3) was impregnated with white, black, red, orange, yellow or blue dyes. The conclusions showed that the beetles did not feed on foliage which had been sprayed with any of the colored chalks, as much as they did on the checks or unsprayed leaves. However, there was no color upon which they did not feed.

These observations were somewhat corroborated by the author's experience with "color-squares." In 1924 differently colored cloths, one foot square, were hung on adjacent trees of an orchard and the beetles, clinging to them, were counted at regular intervals. The cloths alone were not attractive to any extent, so they were dipped in a 10% geraniol emulsion. This attracted the beetles in large numbers but no striking preference for any particular color was observed. In fact, it appeared that, on some days, the white cloth led in numbers attracted. This seemed to contradict some beliefs that white repels, but such attraction may be entirely due to the geraniol present.

McIndoo, 1926, described an insect olfactometer, the principle of which depends upon attraction by light. In 1924 he used this instrument successfully in experimentation with the Japanese beetle. The source of light employed was either the sun's rays or a "daylite" bulb (Edison Mazda, 110 volts and 75 watts). The beetles readily moved from the dark bottle, used in this apparatus, to the y-shaped glass portion connected with it.

II. Discussion of Some Factors Concerned

The expressions of the above authors tend to indicate clearly the value of light in relation to the activities of the beetle. All responses of the adult to light rays show that it is strongly photopositive. However, as Moore and Cole, 1921, have written, negative geotropism and photokinesis must also be taken into consideration.

Evidences of positive phototropism are common in the field and it seems impossible to bring forth strong enough proof to discount any of these observations. On the other hand, when an apparently photonegative response is observed, there seem to be ample reasons for eliminating such a record. For example, the return of the female to the soil for oviposition, although it appears a clear case of negative phototropism or positive geotropism, can be explained as a result of some

potent internal stimulus rather than the direct influence of light or gravity.

Among the activities in nature, which substantiate opinions concerning the desire of the beetle for light, are included emergence from the ground; a primary attack of plants in the open, the tops of trees or the periphery of woodlands; the selection of the upper surfaces of the leaves for feeding with perhaps the exception of peach leaves; the preference for the sunny portions of food plants; and the general inactivity observed on cloudy days even if the temperature and humidity are apparently entirely satisfactory.

Early insecticide results demonstrated clearly the often repeated fact that arsenical sprays usually repel the beetle. Just what the deterrent factors are has always been a much disputed question. Data given in the Sixth Annual Report of the New Jersey State Department of Agriculture, 1921, seemed to indicate very definitely that the beetles object to eating spray deposits consisting of small powdered grains of any nature whether poison or not. Moreover it was stated that the color of the sprays seemed to make little or no difference in this respect.

In 1922, Moore reported that Japanese beetles were not repelled from sprayed foliage by the color, taste, or physical condition of the arsenicals but appeared to be influenced by certain toxic effects resulting from eating some of the poison. Smith, 1923, mentioned these points in his review of the feeding habits of the adult. Kelley and Moore, 1923, in writing on sprays for control expressed the view that the beetle leaves the sprayed foliage on account of toxic effects before obtaining a killing dose. In order to overcome such a difficulty they recommended more thorough spraying and an increase in the strength of the arsenical used.

Van Leeuwen, 1926, stated that the effect on the insect of the color, odor, taste or physical appearance of the deposit was not yet established. The efficacy of the coated arsenate of lead apparently strengthened the toxic hypothesis advanced by Moore in 1922 but there are surely other factors which can not be ignored in this connection.

Such confusion of thoughts led me to consider, in 1924, the relative value of color upon the Japanese beetle and the first attempt was the crude test just mentioned, with the color-squares. Following these investigations, plans for the erection of the phototropic apparatus, described in this paper, were outlined. In using this apparatus it must be remembered that, although its operation is relatively very simple, many factors have to be taken into consideration before drawing too hasty conclusions.

III. Acknowledgments

Considerable credit for the general scheme of this outfit is due Loren B. Smith, who, together with the author, drew up the plans. During the summers of 1925 and 1926, Mathew Jameson and Ezekiel Rivnay, both of the Massachusetts Agricultural College, ably assisted in the conduction of experiments pertaining to these problems.

IV. Description of the Apparatus

(Figures 14, 15 and Plate 12)

The apparatus consists of a wooden cabinet, octagonal in shape, elevated about two and one-half feet from the ground by eight outer and

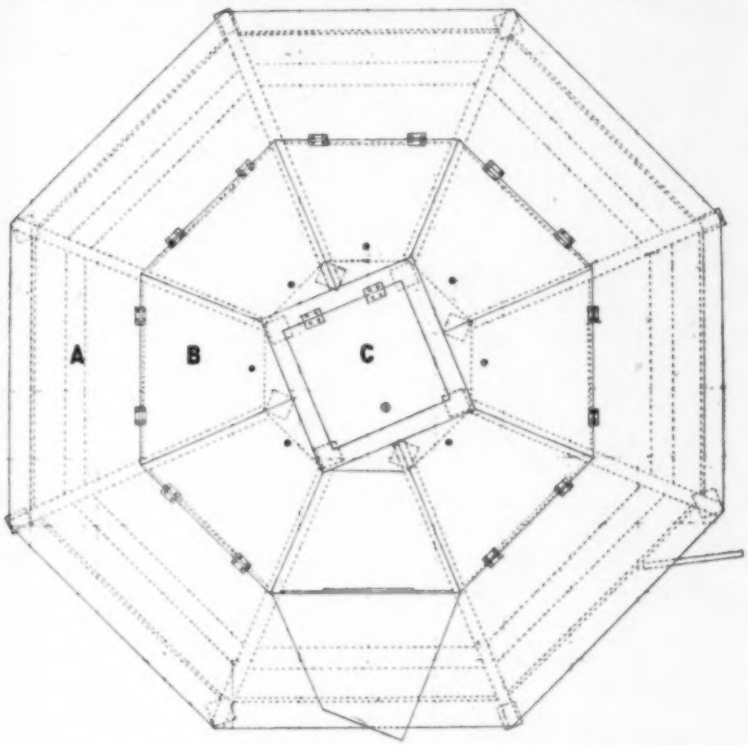

Figure 14.—Drawing of phototropic apparatus from above. (Each large square represents one square foot).

four inner erect joists and placed beneath a shed in order to protect it from the weather. It is thirty-six feet around, the greatest width is

[2]Since this outfit is home-made the inside measurements should be considered as being only approximate.

eleven feet and it is about two feet deep.[2] The material of this structure consists of matched boards, wall board, quarter round stripping, etc. It is coated with a flat white paint inside and out.

In addition to a central chamber (C) there are eight distinct outer compartments, as the form of the apparatus suggests. Each compartment is composed of an outer or lighting chamber (A) and an inner or color chamber (B). Between these two chambers are two apertures for the reception of glass color filters, six and a half inches square. These are held in position by wooden strips, placed on both sides of the partition and fastened with bolts. The filters can thus be readily removed or interchanged.

Chamber A is sixteen and a half inches long and eighteen inches high. It is thirty-four inches wide at the partition, separating this chamber from chamber B, and forty-eight inches wide at the outer wall. The chamber is well aerated from beneath by holes and by a space between the outer wall and the top so as to prevent the temperature from becoming too high. Wall boards properly placed prevent the entry of any direct light rays from the outside. Entrance to this chamber is attained by a door made in the outer wall.

Each lighting chamber is equipped with two lamp sockets, mounted on a movable stand and seven inches apart, for the insertion of electric light bulbs. Nitrogen-filled "Mazda" bulbs have been used in the tests. The sockets are so placed that each bulb is opposite a color filter. The electric feed wire furnishes 220 volts A. C., but this is reduced to 110 volts before entering the circuit in which the above lamps are arranged in parallels. Number fourteen covered wire was used.

Chamber B is twenty-three and a half inches long and eighteen inches and a half high. At the outer partition, containing the two filters, it is thirty-four inches wide, while the side towards the center measures sixteen inches. A door in the top allows access to this chamber from above and an aperture leads to Chamber C. This latter opening is nine and a half inches wide by twelve inches high and it is so grooved at the sides as to allow the insertion of a metal partition for the isolation of Chamber B from Chamber C. Each chamber is numbered consecutively 1–8.

In all experiments to date colored glasses, manufactured by the Corning Glass Works of Corning, New York, have been used for the filters. Selenium Red (G24); Selenium Orange (G34); Yellow or Noviol (G38H); "Grass" Green (G401CZ); Dark Blue (G54); Violet (G53C) and Daylite (G90A) represent the seven different types of filters tested.

General view of apparatus.

Chamber three was unlighted and was thus designated as the dark chamber.

Chamber C is fifteen inches high and about three feet across. The floor is two and one-half inches above that of the other chambers. At the top of this chamber is a square door with a central hole for observation. The hole is filled with a cork stopper when not in use.

V. Method of Procedure

Inasmuch as there were many factors to be taken into consideration, regarding the use of this new apparatus, it became necessary to conduct a number of special experiments before deciding upon the customary

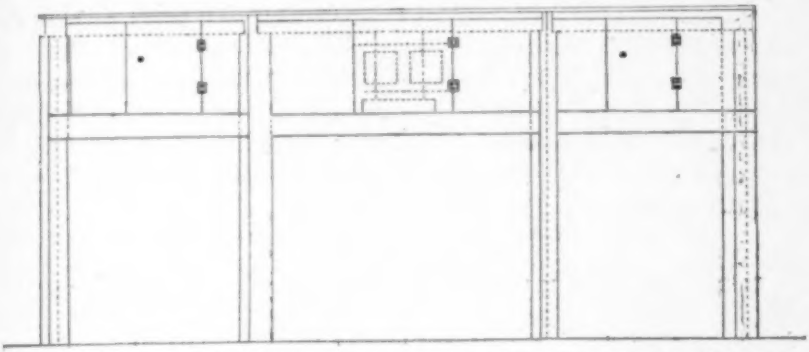

Figure 15.—Drawing of phototropic apparatus from the side. (Each large square represents one square foot).

method of treatment. The main questions at hand included the length of exposure to light rays, the numbers of beetles to be tested, the number of times the same individuals should be used, the value of segregating the sexes and the advisability of keeping them in the darkness before testing.

Thus the procedure varied somewhat during the preliminary tests, but in most of the succeeding experiments it was proved desirable to test the sexes separately, keep the beetles in the dark for half an hour before testing them, handle them as little as possible, use a different set of individuals for each test, run three tests for each experiment and allow a two hour period for their migration to the color chambers.

In general the beetles were gathered at random the first thing in the morning and, after being separated according to sexes, they were placed in some sort of a container. In the meantime the chambers were lighted as desired and the beetles when ready were deposited in the center of Chamber C. The usual two hours were then allowed for them to make

their choice of chambers. At the close of a test the metal partitions were inserted, the beetles removed from the respective color chambers and counted. To better visualize the results the number of beetles attracted were grouped according to the number of the chamber selected. The temperature and humidity were taken at the beginning and conclusion of each test.

VI. Experimentation in 1925 and 1926

Over one hundred experiments were conducted during the summers of 1925 and 1926. It has been impossible to work over the results carefully enough to include them in this paper, but perhaps the following list of the main problems will give the reader a better idea concerning the lines of investigation. 1. Preliminary tests (see Section V above). 2. Sequence of choice, using all filters or with some omitted. 3. Choice of chambers when only two are used. 4. Attraction when only one chamber is lighted. 5. Repetition of choice. 6. Effect of reduction in candle power (watts). 7. Color choice when the intensity of illumination in all chambers is equalized. 8. Effect of changes in the size and shape of the aperture between Chambers B and C.

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President Arthur Gibson: The next is a paper by B. R. Leach and J. W. Lipp. Mr. Leach read the paper.

A METHOD OF GRUB-PROOFING TURF

By B. R. Leach & J. W. Lipp, *Riverton, N. J.*

Abstract

The use of arsenate of lead mixed with the soil to a depth of three or four inches before seeding, or used in the top dressing on turf already established is described. The method is proving satisfactory in practice. The large majority of fine turf grasses are stimulated in their growth by the present of the poison on the soil.

(Withdrawn for publication elsewhere)

Mr. C. C. Hamilton: I would like to ask Mr. Leach if the treating of the turf with lead arsenate prevents oviposition and for what length of time the turf is proof against grub infestation.

Mr. B. R. Leach: I don't think it prevents oviposition. We have seen plenty of beetles going into poisoned turf. As I said during the talk, we were fortunate in starting some poisoned plats in 1921 and we know from the basis of those plats that it is good for five years, apparently only slightly diminished. How long it will remain good, we don't know.

Mr. C. C. Hamilton: That was at the rate of 1500 pounds?

Mr. B. R. Leach: Yes, 1500 pounds. After you have put arsenate of lead in the soil, there is a certain breakdown, and we figure it amounts to about 500 pounds to the acre, and after that breakdown has occurred, it seems to remain, from the toxic angle, constant over relatively long periods.

President Arthur Gibson: The last paper on the program is by Henry Fox.

THE PRESENT RANGE OF THE JAPANESE BEETLE, *POPILLIA JAPONICA* NEWM., IN AMERICA AND SOME FACTORS INFLUENCING ITS SPREAD[1]

By Henry Fox, *Associate Entomologist, Japanese Beetle Project, U. S. Bureau of Entomology*

Abstract

The apparent total range—here termed the empiric range—consists of two sections, in one of which, the normal range, the insect is continuously distributed, while in the other, the area of discontinuity, it is known only from widely isolated points. Occupation of the normal range has resulted largely from natural spread, while its occurrence in the area of discontinuity is a result of long-distance transfer through artificial agencies. Within the normal range the main direction of spread is eastward, a result which is attributable to the combined action of prevailing winds and topographic influences. The apparent effects of these two factors in conditioning the rate of

[1]Contribution No. 17, Japanese Beetle Laboratory.

spread of the insect are discussed. Maps are included showing the normal range and approximate concentration of the beetles for the years 1925 and 1926.

Since its discovery in this country in 1916 near Riverton, New Jersey, the Japanese beetle has steadily extended its range until the latter now includes parts of six States. The maps hitherto published to show the successive stages in the spread of the pest do not, however, discriminate between that portion of its range in which the insect is of general occurrence and that in which it is known only from more or less widely separated stations, with no clear evidence of its presence anywhere in the intervening territory. The former presumably represents a region populated by the beetle as a result of the more ordinary methods of dispersal,[2] whereas its occurrence in localities widely isolated from this region, as also from one another, can scarcely be explained except as a result of long distance transportation through exclusively artificial agencies.

In the present paper I have chosen to designate that portion of the beetle's range in which it is of general occurrence as its "normal range," while all that portion outside the normal range where, so far as known, the insect is confined to isolated stations, I have termed the "area of discontinuity." The "normal range" plus the "area of discontinuity" constitutes the apparent total range, for which I have selected the term "empiric range." The empiric range is naturally defined by a line passing through the outermost points at which the species has been found, irrespective of whether beetles have or have not been found in the intervening country. It is clear, therefore, that much of the country which is included within the empiric range may include vast areas in which there is no present evidence of the actual presence of the pest. On the other hand, the normal range, as defined above, represents a section of the country in which the insect is more or less uniformly distributed.

Previous to 1923 the empiric range of the beetle, as portrayed on the published maps,[3] closely coincides, even if in all details it is not identical,

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[2]By ordinary methods of dispersal I mean besides natural methods, such artificial methods as are conceivably afforded by local motor traffic and kindred methods of travel in a limited district. There seems to be some, not entirely clear, evidence that the natural spread of the beetle throughout its present normal range has been partially aided by motor traffic through the originally infested district. At present it is not possible for us to distinguish between local spread due to this cause and that resulting exclusively from natural causes.

[3]See Smith and Hadley, The Japanese Beetle. U. S. Dept. Agric. Dept. Circ. 363 (1926), facing page 6.

with its normal range. But, beginning with 1923, there ensued a remarkable acceleration of the rate of spread which can only be explained by assuming that some factor of dispersal, not previously operative, had come into play. This factor I find in the fact that in 1922 for the first time the beetles invaded the great freight and shipping centers in the cities of Camden and Philadelphia. As a result of their becoming accidentally imprisoned in freight cars, shipholds and other closed conveyances, beetles would be carried away from these centers with no chance to escape until their conveyance reached its destination. The imposing of an embargo on commercial shipments from these cities at times when the beetles swarmed about in threatening numbers reduced this mode of dissemination of the insect to a minimum. Since it has been hitherto impossible to predict the precise time of occurrence of these invasions, it has happened that occasionally living beetles have been found at a distance in freight cars which had left the city before the embargo could be put into effect. Moreover there has come about, within the past few years, in the heavily infested area, an increased use of motor vehicles to transport farm produce to distant points accessible to this form of traffic. There is, accordingly, good ground for assuming that the sudden leap in the beetle's range which characterized the season of 1923 and which has been a marked feature of its subsequent spread, is not to be attributed to any sudden increase in the innate dispersive capacity of the insect itself, but to the fact that, as a result of these two conditions, neither operative on an extensive scale previous to 1922, its artificial dissemination through these means became factors of major importance in extending the insects' apparent range.

In view of the introduction of this new factor in dispersal, there has come about since 1922 a progressively increasing discrepancy between the total, or empiric, range of the beetles and that which I have defined as its normal range, the former expanding at a vastly greater rate than the latter. For example, in 1926, the empiric range extended northeast as far as Stamford, Connecticut, Ossining, New York, and Hackensack, New Jersey, north to Lake Hopatcong and Phillipsburg, New Jersey, and Easton, Allentown and Milton, Pennsylvania, west to Harrisburg and Gettysburg, Pennsylvania, and south and southwest to Delaware City, Delaware, Baltimore, Maryland, and Washington, District of Columbia. In the same year (Fig. 17) the normal range is approximately limited north and northeastward by such localities as Frenchtown, Kingston, Jamesburg and Freehold, New Jersey, east by the Atlantic Ocean, south by such places as Egg Harbor City, Richland,

Millville and Hancock Bridge, New Jersey, while to the west the same range is roughly limited by a line extending from New Hope, through such localities as Doylestown, Lansdale, Norristown and Media, Pennsylvania, to Wilmington, Delaware.

In the following table are listed the distances to which the normal range of the beetle, as previously defined, has expanded in various directions from the point near Riverton where it was first introduced in this country.

TABULATION OF NORMAL RANGE

Direction	Locality	Distance from Riverton
North	Frenchtown, N. J.	38 miles
North Northeast	Kingston, N. J.	33 "
Northeast	Jamesburg, N. J.	38 "
East Northeast	Freehold, N. J.	41 "
East	Toms River, N. J.	43 "
East Southeast	Barnegat, N. J.	45 "
Southeast	Port Republic, N. J.	43 "
South Southeast	Richland, N. J.	35 "
South	Millville, N. J.	42 "
South Southeast	Shiloh, N. J.	41 "
Southwest	Hancock Bridge, N. J.	42 "
West Southwest	Wilmington, Del.[1]	33 "
West	Newtown Square, Pa.	22 "
West Northwest	Norristown, Pa.	21 "
Northwest	Lansdale, Pa.	24 "
North Northwest	Doylestown, Pa.	24 "

[1]If, as has been done on the map, the 1926 limits in this direction are extended as far as Delaware City, this distance becomes 43 miles. As in 1926 no beetles were found anywhere in Delaware south of Wilmington, except at New Castle and Delaware City, it seems doubtful if we are justified in extending the normal range for that year below Wilmington.

The fact most clearly brought out in this table is the retardation of its westward as compared with the eastward expansion of the insect's range. In general, this is equivalent to saying that its progress in Pennsylvania has been considerably less rapid than in New Jersey.

To account for this difference in the rate of spread of the beetle in the two states, the factors which most obviously suggest themselves as possible explanations are wind direction and topographic features.

In favor of wind direction as a factor in conditioning the dispersal of the beetle may be mentioned the coincidence between the main direction of its spread and the general prevalence in the region, during the season of the beetle's activity, of west and southwest winds. These are also warm winds which ordinarily stimulate the insect to increased activity and thus increase its chances of dispersal. As our field observations

indicate that the beetle in flying ordinarily goes with the wind, provided the mechanical action of the wind is not counteracted by influences of an opposing nature,[4] it seems but reasonable to assume that conveyance by the wind is not without influence on its rate of spread.

As an objection to this view may be urged the fact, as shown in the table, that the distance the beetle has covered in its spread from its original center to the present limits of its normal range has been nearly, if not quite, as great in both a direct northward and a southward direction as it has been in an eastward direction, at least, so far as its range in New Jersey is concerned. This objection may perhaps be met in part by considering two features connected with the eastward movement. One of these is the relative concentration of the insect near the limits of its normal range, the other the influence of a forest cover on the rate of spread.

As regards the first mentioned matter, the available evidence indicates rather clearly that there is a much greater tendency for the beetles to occur in greater numbers at certain points close to the eastern limits of the insect's range than is the case at equally favorable localities close to its northern and southern limits. This fact, it is true, tends to lose some of its force when it is borne in mind that this eastward movement of the mass of the beetles may have been very considerably favored by the heavy summer tourist travel to the seashore resorts. But this objection is again partly nullified by the fact that the eastward spread of the beetle, in some instances, has been more marked along some

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[4]Of the opposing influences the more potent are chemotropic responses by the insect to certain odors given off by the vegetation and conveyed to the insects by the wind. Smith and Hadley in a recent publication (loc. cit., p. 33) assert that the beetles normally fly against the wind. This is true if we limit our observations to stations where the beetles are in a favorable position to receive such stimuli as those mentioned. Under such circumstances the flight of the insects against the wind is a most impressive phenomenon as the present writer can testify from his personal field observations. But, when the beetles are observed in other situations where they are remote from such influences, nothing like a definite response to wind direction is observable, and under such conditions their flight is essentially aimless, the general drift being, however, with the wind. That the mechanical action of the wind is not without influence on the direction of flight is further evidenced by the observation that the so-called migratory flight of the beetle which recurs at sundry intervals into the business centers of Philadelphia invariably coincides with periods during which for the time being the wind has shifted about to the east. Such east winds doubtless serve to convey a much greater number of beetles from their breeding grounds in New Jersey across the Delaware into the city than succeed in reaching the latter during the times when the prevailing westerly breezes hold sway.

comparatively unfrequented lines of travel than it has along certain other lines where the seashore motor travel is extremely heavy.

As regards the second point raised as influencing the eastward rate of advance, namely, the influence of a forest cover, it is well known that the greater part of the interior of southern New Jersey forms a heavily timbered region known as the Pine Barrens. While a heavily forested region does not interpose a very formidable barrier to the Japanese beetle, it offers relatively few favorable breeding or feeding areas and hence acts as a retarding influence on the rate of advance. It is well known that the Japanese beetle favors an open, campestral type of country and it is a matter of observation in the New Jersey Pine Barrens that it normally occurs in considerable numbers only in areas where the forest has been cleared off and the land converted into farms, gardens and other open spaces. It seems highly probable that, if the Pine Barren region of the State had presented throughout conditions similar to those in the Delaware Valley section, the eastward advance of the beetle would have taken place much more rapidly than has been the case.

While there appears to be much to favor wind direction as affording an adequate explanation of the present eastward trend of the normal range of the beetle, there are good grounds for believing that other factors have been involved, of which the more important may be grouped under the general head of effects of topography.[5] That the rapid spread of the Japanese beetle is favored by a type of topography which is characterized by such features as extensive tracts of nearly level, or at most gently rolling, country, along with deep, friable soils, capable of retaining throughout the year a fairly high water content, yet so situated as to allow ready aeration, has long been noted. Such a type of topography is extensively represented in the Coastal Plain section of New Jersey, to which section the normal range of the beetle in that State has until quite recently been entirely confined.

On the other hand, with its spread across the Delaware into Pennsylvania, the beetle had but a few miles to travel before it reached the Fall Line which marks the boundary between the Coastal Plain and an

[5]The writer realizes that topography *per se* does not constitute a factor conditioning dispersal; it is, strictly speaking, the complex of conditions depending on topography which form the more immediate agencies influencing distribution. Thus, topography may have a profound influence in determining such matters as the composition, texture, depth and moisture content of the soil and these in turn may profoundly influence the distribution of the various forms of plant life on which the beetles or their larvae feed.

upland region which physiographically is distinguished as the Piedmont Plateau. The latter is a region of considerably greater altitude than the Coastal Plain, with a more rugged topography in which areas of level or nearly level country are of localized occurrence and limited extent. The soils of the Piedmont region are also quite different. With the

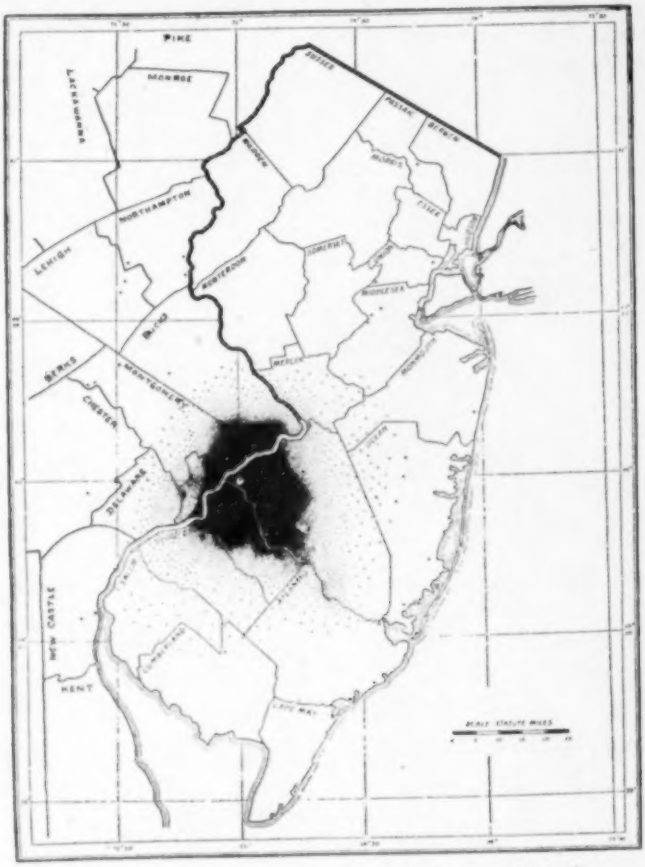


Fig. 16.—Relative frequency of the Japanese beetle in its distribution area in 1925.

exception of the alluvium of the river bottoms, they are prevailingly stiff heavy clays and loams, often of little depth, especially on steeper slopes, and frequently quite stony. These are the conditions to which the beetle has been forced to adapt itself in the westward extension of its range through Pennsylvania, and that it is experiencing at least a certain measure of difficulty in doing this is indicated by the fact that in certain

Piedmont localities, as, for instance, about Willow Grove, where it has been known since 1923, it is to-day scarcely more in evidence than it was

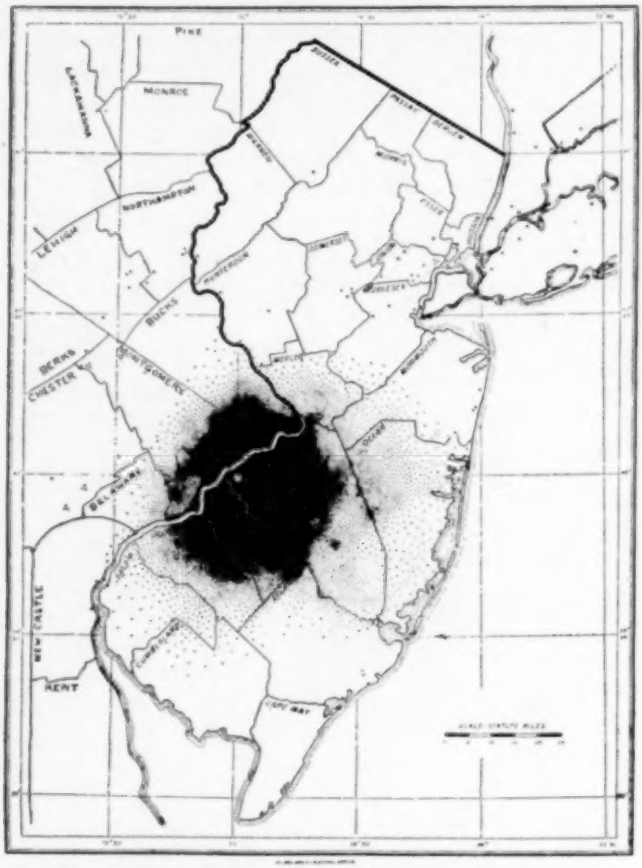


Fig. 17.—Relative Frequency of the Japanese beetle in its distribution area in 1926.[6]

[6]In both this and the preceding figure the density of the dots is roughly proportional to the density of the beetle population in different parts of its normal range. The normal range is defined by the outermost row of dots limiting the area in which the dots are placed at regular intervals apart. The small circular blank space within this area represents the original center from which the beetle began its spread. The solid black area represents the region in which the beetle is abundant enough to be economically injurious.

The dots scattered about at varying intervals in the section outside the normal range represent localities where beetles have been found in the "area of discontinuity." Certain localities in the latter (e. g. Reading, Harrisburg, Milton, etc.) are too remote to be included in the maps.

when first encountered in those places. On the other hand, in most Coastal Plain localities rarely more than two years elapsed following its appearance before it had reached a point where its destructiveness was obvious to even the casual observer.

While there would appear to be much to favor the view that influences arising from topography are capable of accounting for the delay which the beetle has experienced in its advance in Pennsylvania, we need to be on our guard against a too hasty acceptance of this explanation. The main ground for an exercise of caution in this matter lies in the fact that the whole subject of the adaptability of the Japanese beetle to Piedmont environmental conditions is still under investigation and that our present knowledge is not of that detailed, analytic character which would enable us to assign to each possible factor its proportionate share in conditioning the spread of the insect. Moreover, we do not have at the present time any clear criterion for distinguishing between dispersal controlled primarily by the wind and that which is conditioned chiefly by topography. In view of this uncertainty we are compelled to treat each possible explanation as nothing more than a suggestion whose validity is to be tested through future investigation. From the point of view of our present knowledge of the behavior of the Japanese beetle, the factors which seem to offer most promise as influencing its natural spread are direction of prevailing winds and topography.

For the sake of comparison there is included in this paper a chart (Fig. 16) showing the distribution and relative concentration in different parts of its normal range of the Japanese beetle as it was in 1925. By comparison with the similar chart (Fig. 17) for 1926 one can form an idea of the yearly amount of spread. One noteworthy feature shown by the charts, which has not hitherto been mentioned in this paper, is the striking retardation of the spread which is shown through the heavily built-up sections of Philadelphia, where suitable feeding and breeding grounds for the beetle are naturally reduced to a minimum. Paradoxical as it may seem, a large city, like Philadelphia, may have two opposite effects on the dispersal of the beetle. It puts a brake on the local extension of the range, but, by increasing the opportunities for long distance conveyance of the insect through artificial agencies, it serves to accelerate the extension of its empiric range.

(After the reading of Mr. Fox's paper, which closed the program of papers, the final business was transacted which appears in the business proceedings.)

A PRELIMINARY REPORT ON A GRASS-ROOT MEALYBUG (*RIPERSIA RADICICOLA* MORRISON) AFFECTING SUGAR CANE IN CUBA[1]

By C. F. STAHL, *Chief Entomologist*

ABSTRACT

A typical root-feeding mealybug (*Ripersia radicicola* Morrison) is found well distributed over the Island of Cuba on the roots of grasses and sugar cane.

The mealybug is probably a native species which inhabits the roots of grasses and has adapted itself to sugar cane.

"Grass-root mealybug" is suggested as the common name for this insect in preference to "sugar cane root mealybug," inasmuch as wild grasses are the primary host plants.

The area of injury does not coincide with the area of distribution. Serious injury occurs in soils subject to drought where the mealybug appears to be only one of several factors unfavorable to the growth of the plant.

The use of legume cover crops in areas where the grass-root mealybug is a serious pest, to improve the soil and suppress the grass hosts, is under consideration.

During the past two years considerable interest has been manifested in a mealybug found feeding upon the roots of sugar cane in several localities in Cuba. This interest has been intensified by the fact that the insect was reported as undescribed, which led some to believe that it was a pest recently introduced into Cuba. An effort has been made to obtain as much information concerning this insect as other work in progress would allow. The purpose of this paper is to summarize these observations and to discuss certain points that they raise.

"Mealybug" and "chinche harinosa" are terms familiar to all who have had experience in growing sugar cane. Besides the mealybug under discussion, which occurs on the roots of grasses and sugar cane, two species of stalk mealybugs have been encountered in Cuba. They are widely distributed. They are red or gray soft-bodied insects, covered with a white powdery or fluffy substance, occurring in clusters, usually at the nodes under the leaf-sheaths of the cane stalks. It is the white powdery covering that is responsible for the common names "mealybug" and "chinche harinosa."

While the general appearance of mealybugs feeding on a plant is such that they may be easily recognized as a group, it is not so easy to distinguish between the different species. The common stalk forms may be found on the cane from the time it starts to germinate, and they are often seen beneath the surface of the ground, clustered around a germinating bud, or at the base of growing stalks. It would not, there-

[1]Scientific Contributions No. 8, Tropical Plant Research Foundation. From the Cuba Sugar Club Experiment Station, Central Baraguá, Cuba.

fore, be surprising if another species feeding on the roots was thought to be identical with the stalk species and if the fact that this other species constituted a potential pest had been entirely overlooked. Such seems to have been the case.

No reference to the occurrence of a root-feeding mealybug on sugar cane in Cuba has been found in the available published reports prior to 1924. However, mealybugs were observed on the roots of sugar cane growing at Central Stewart in 1916 by Mr. J. T. Crawley, who was at that time director of the Agricultural Experiment Station at Santiago de las Vegas. As this observation was never published, Mr. Crawley has kindly furnished his notes, which are quoted as follows:

"October 3, 1916. Fields are very uneven and there are many spots near the roads that are not thriving. Numbers of mealybugs, comejens and beetle grubs were found at the roots of cane. Easy to pull up. Probably 5 to 10% of the old fields so affected. Mealybugs are most abundant, both on the cane and at the roots of cane examined." Mr. Crawley stated that he could remember that the mealybugs in question were often noted on the smaller roots, but he did not attach any particular significance to the fact at that time. It is very probable, in the light of what is now known concerning the distribution of the grass-root mealybug, that Mr. Crawley observed this insect at that time. It can therefore be stated with reasonable certainty that the root-feeding mealybug was present on the roots of sugar cane in some districts of Cuba as early as 1916.

In October, 1924, attention was called to a mealybug designated as *Ripersia* sp. (2),[2] which was found infesting the roots of sugar cane in Cuba. Ballou (1, p. 46), in his list of scale insects and mealybugs of Cuba, published in April, 1926, includes *Ripersia* sp. as having been collected at Camagüey by Bruner in 1923. Van Dine (6, p. 11–12) records *Ripersia* sp. in his list of sugar cane insects and mentions its occurrence on the roots of numerous grasses in the Provinces of Oriente and Camagüey. Myers (5, p. 99) also mentions *Ripersia* sp. as having been observed at Soledad in Santa Clara Province. Finally, in October, 1926, Morrison (4) published a description of the species under the name *Ripersia radicicola* n. sp., basing his description on material submitted from the Provinces of Oriente, Camagüey, and Santa Clara.

The tendency at first was to refer to this insect as "the sugar cane root mealybug," a name which would indicate that sugar cane was of primary importance as its host plant. As will be shown later, this does

[2]Numbers in parenthesis refer to references listed at the end of the paper.

not seem to be the case. The common name "grass-root mealybug" is suggested because of the importance of wild grasses as host plants.

If this root mealybug limited its feeding to the roots of sugar cane, or even showed a preference for them, it might appear to be a pest which had been introduced in some way as a result of the extension of cane planting. It has been repeatedly observed that many different species of grasses are infested, and in many cases it is evident that the infestation is in no way related to the planting of sugar cane. In fact, infestations have been noted on the roots of grasses growing adjacent to cane fields in which the roots of cane stools were found upon examination to be uninfested. In a few cases mealybugs have been found on grasses growing in areas far removed from cane fields.

On the basis of these observations it is reasonable to assume that the root mealybug is a typical grass-root feeding species, that it is probably native or at least that it has been present in Cuba for a long time, and that under changing cultural conditions, brought about by the rapid extension of cane plantings, it has spread to the roots of sugar cane.

The distribution of the grass-root mealybug over the Island has not been fully determined. It was first noted by the writer on the roots of grasses and sugar cane growing on the plantation of Ingenio Jobabo. The infestations there were limited to areas where the soil was comparatively light and well drained. Records were made of infestations on the roots of grasses growing on ditch banks, in guardarrayas, along the edges of cane fields, and, in some cases, well within the cane fields. When the infestations were found on the roots of sugar cane, their location often indicated that the source might have been the adjacent guardarrayas, in as much as the areas infested were usually small semicircular patches spreading from the edges of the fields. This was especially true where the guardarrayas had been planted to sweet potatoes (boniatos) and the natural grass hosts had in this way been suppressed. Later, more widespread infestations were found in the Province of Camagüey.

The following fragmentary records are given to indicate the localities in which the grass-root mealybug has been found. These records are taken from the survey reports made by Dr. Wm. H. Weston, Jr., Dr. R. V. Allison, and other members of the staff of the Tropical Plant Research Foundation. While these records indicate the presence of the mealybugs in the localities observed, they do not furnish information regarding the abundance or extent of the infestations, nor do they show the limits of distribution. The authority for the observations is given in parenthesis.

ORIENTE PROVINCE

Central Isabel, Media Luna (Allison)
Ingenio Jobabo (Stahl)

CAMAGÜEY PROVINCE

Central Agramonte (Weston and Van Dine)
Central Baraguá (Stahl)
Central Cunagua (Van Dine)
Central Estrella (Allison)
Central Florida (Weston)
Central Francisco (Allison)
Central Jagueyal (Van Dine)
Central Jaronú (Poey)

SANTA CLARA PROVINCE

Central Hormiguero (Faris)
Central Portugalete (Allison)
Central Soledad (Myers)
Central Tuinucú (Weston)

As has been mentioned before, the grass-root mealybug has been found on the roots of a large number of grasses. The following is a list of these plants as far as they have been determined.

Cenchrus echinatus	guizazo
Valota insularis	barba de indio
Echinochloa colonum	grama pintada
Syntherisma sanguinalis	pata de gallina
Panicum reptans	grama de Castilla
Panicum fasciculatum	súrbana
Cynodon dactylon	hierba fina
Eleusine indica	grama de caballo
Sporobolus indicus	espartillo
Chloris ciliata	
Chaetochloa geniculata	rabo de gato
Leptochloa filiformis	pata de gallina
Sorghum spp	millo
Zea mays (corn)	maíz
Saccharum officinarum	caña de azúcar
Cyperus sp	cebollita

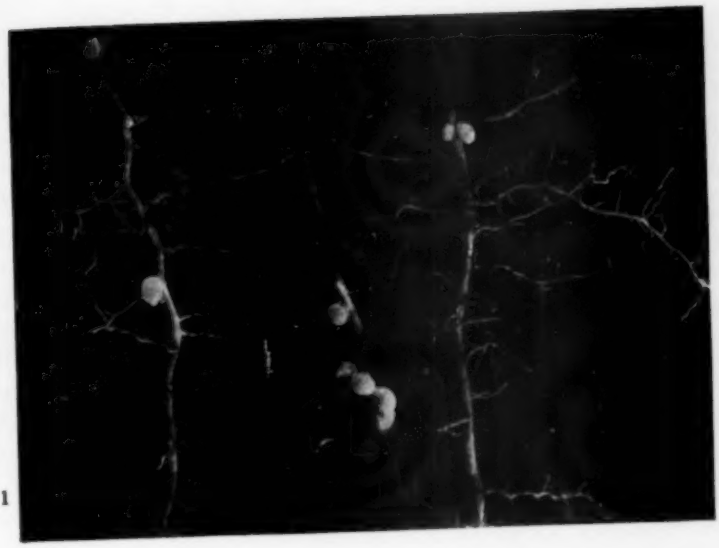
Most of the grasses were determined by Dr. M. N. Walker, formerly Pathologist at the Cuba Sugar Club Experiment Station, and the identifications were confirmed by Dr. A. S. Hitchcock of the United States Department of Agriculture, who also determined *Chloris ciliata*. The identification of *Sporobolus indicus* was made by Dr. J. A. Faris, Chief Pathologist of this Station. Dr. Weston reported *Cyperus rotundus* as infested with root mealybugs at Tuinucú, and Mr. B. T. Barreto

reports that he has collected the grass-root mealybug on the roots of Johnson grass (*Holcus halepensis*).

It will be noted that the majority of the grasses which have been found to be infested are annuals. This does not necessarily mean that the perennials are not host plants, but it indicates that the annual grasses are of primary importance as hosts. Roots of such grasses as paraná (*Panicum barbinode*) and Guinea grass (*Panicum maximum*) growing in infested areas have been examined many times, but the root mealybug has never been found on them.

It is not possible with the literature available to discuss in detail the relation between the grass-root mealybug and other root-inhabiting mealybugs. A number of reports have, however, been noted in which the occurrence of mealybugs on the roots of sugar cane and grasses in other countries has been mentioned. Lefroy (3, p. 759) mentions *Ripersia sacchari* Cr. as living on cane as well as on rice and grasses in India but does not state that it is found on the roots. *Ripersia internodii* Hall, reported by Willcocks (7) from Egypt, appears to be a species that feeds on grasses and sugar cane, both above and below the ground. It is, however, said to feed on the nodes and internodes of sugar cane. In the same report *Pseudococcus variabilis* Hall is mentioned as a common grass-root feeding species which is found well up on the jointed canes and around the nodes of sugar cane. *Pseudococcus trispinosus* Hall is also reported as feeding on the roots of sugar cane and grasses. From these scattered reports it will be seen that it is not uncommon to find the roots of grasses infested with mealybugs, as well as sugar cane.

As a rule it is not difficult to recognize the grass-root mealybug in the field. Perhaps the one species most apt to be confused with it is the gray sugar cane mealybug (*Pseudococcus boninsis* Kuwana), found commonly on the stalks of sugar cane in Cuba. This stalk mealybug may be distinguished from the root mealybug in several ways. It is somewhat larger, is covered with a more dense waxy-like secretion, and is flatter. The root species is distinctly globular in shape, and the conspicuous pink tinge can be seen through the sparse powdery secretion. Perhaps, however, the best way to distinguish between the two species is by means of their feeding position on the plant. The stalk mealybug is usually found on the stalk above the ground, but when it is found below the surface of the ground it has always been in the crown at the base of the stalks or around the germinating buds (Pl. 13, Fig. 2, 3). The root mealybug, on the other hand, has always been found on the roots and usually on the small rootlets, which spread out some distance from



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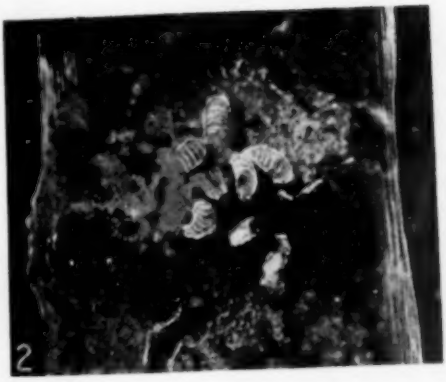

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Grass Root Mealybug, *Ripersia radicicola* Morrison.
1, Mealybugs clinging to the roots of sugar cane. (Original).
Sugar Cane Stalk Mealybug, *Pseudococcus boninsis* Kuwana (Van Dine).
2, Mealybugs on node of sugar cane after leaf sheath has been removed.
3, Mealybugs clustered about the base of young cane stalks.

the base of the plant. The stalk species has not been found on grass, but it may be present on some of them, especially the large cultivated types. When a plant is pulled up some of the root mealybugs usually cling to the roots by means of their mouth parts, which they insert in the tissue of the roots (Pl. 13, Fig. 1).

There are other underground mealybugs which are commonly found on weeds and grasses in Cuba. A common weed, romerillo (*Bidens* sp.) is frequently found to be infested with mealybugs below the surface of the ground, and it has been reported that romerillo is responsible for the presence of the grass-root mealybugs in the cane fields. The species feeding on romerillo is found on the underground portion of the stems rather than on the roots, and it has not been found on the roots of sugar cane. Several grasses have been found to be infested in the crown by the romerillo species, which Dr. Morrison has determined as *Pseudococcus virgatus* Ckll.

In common with other mealybugs, the grass-root mealybug is always attended by ants, which care for and protect them in return for a sweet substance known as honeydew secreted by the mealybugs. The most common attending ant is a small, inconspicuous, almost black species, which has been determined by Dr. W. N. Mann of the United States Department of Agriculture as *Tapinoma melanocephalum* Fabr. This ant, whose nests have been found at the base of the infested plants, is very assiduous in its attentions, and when the mealybugs are disturbed will pick them up and scurry about in search of a hiding place for them. It is very probable that these ants are largely responsible for the spread of the mealybugs. In fact, plants grown in pots for experimental purposes have become infested in such a way as to show conclusively that the mealybugs had been placed on the roots by the ants. Myers (5) reports a large ant (*Odontomachus haematoda insularis* Wheeler) in close association with the grass-root mealybug in the Soledad (Cienfuegos) area. Occasionally the fire ant, hormiga brava (*Solenopsis geminata* Fabr.), has been found associated with the grass-root mealybug, but the fire ant is more commonly found attending the stalk mealybugs.

There is some question in regard to the amount of injury that should be attributed to the grass-root mealybug. In areas of light soil, under drought conditions, this insect may cause severe injury to sugar cane. The damage is apparent where other factors, especially soil and drainage conditions are unfavorable to the growth of the plant. In many cases the plants are killed in small areas. Under these conditions it has been almost impossible to obtain a new stand of cane. An uneven stand of

cane has been observed in many Cuban fields, the vacant areas having grown up to grasses, which are often infested with root mealybugs. Grasses growing in these vacant areas perpetuate and augment the infestation, and consequently the areas become no longer suitable for growing cane. Unless the mealybugs are suppressed, or the grasses, or the conditions that favor their development are corrected, it is difficult to replant these areas. On the other hand, under favorable growing

Fig. 18.—Plots of Sword Beans (*Canavali gladiata*) in the foreground, showing the vigorous growth and excellent cover made by this plant. (Original).

conditions, vigorous cane plants have been found to be heavily infested with root mealybugs. Often fields are found in which the plants are comparatively heavily infested but do not show any visible effect of the infestation. In other words, the area of injury from root mealybug does not coincide with the area of its distribution. It is probable, therefore, that the severe injury which follows a heavy infestation of the grass-root mealybug results from a number of unfavorable factors, of which the mealybug is only one.

The fact that so many grasses serve as hosts for the grass-root mealybug complicates the problem of control. Any expensive method of soil treatment would obviously be impractical if the importance of the presence of the grasses was overlooked. There is some evidence showing the relation of ants to the distribution of the mealybugs which would indicate that the reinfestation of treated areas will be a serious problem as long as there are grasses growing in the vicinity. In view of these considerations and until a more careful study has been made of all the

factors concerned, soil fumigation does not seem likely to be a practical method of control.

The possibility of utilizing certain legumes for cover crops, as a means of improving the condition of the soil and suppressing the grasses in badly infested areas, has been considered. Certain legumes, such as sword and jack beans, make a rapid, dense growth which seems to be very effective in keeping down weeds and grasses (Fig. 18). These beans are not host plants for the grass-root mealybug. Their value in farm practice as a means of soil improvement has long been recognized. A series of small plots has therefore been laid out in a heavily infested area where the injury is apparent. By means of these plots, observations may be made as to the efficiency of cover crops in suppressing the grass host plants of the mealybug and thus starving it out of the areas. The value of such crops as a means of correcting the poor soil condition can be determined, and also the growth habits of the beans under different seasonal conditions. It is hoped that observation of these plots may give suggestions which may later result in definite recommendations for the improvement of areas badly infested with mealybugs and lead to the discovery of practical control measures.

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INSECT REVIVAL AFTER FUMIGATION[1]

By J. C. HAMLIN, *Associate Entomologist*, and W. D. REED, *Assistant Entomologist*, *Stored Product Insect Investigations, Bureau of Entomology*

ABSTRACT

Saw-toothed grain beetle (*Oryzaephilus surinamensis*) adults and the Indian-meal moth (*Plodia interpunctella*) larvae fumigated with carbon disulphid at atmospheric pressure revive under certain conditions as much as ten and fifteen days, respectively, after treatment. Several larvae of the latter species which revived a week or more after fumigation subsequently emerged as adults. With these species, under the conditions outlined, accurate results cannot be secured by final examination twenty-four to forty-eight hours after fumigation.

INTRODUCTION

Casual reference to entomological literature shows that few data are available concerning two points of procedure in experimental fumigation: namely, the length of time elapsing between fumigation and determination of results, and the revival capabilities of treated insects. The references bearing upon these questions which were encountered in our cursory survey of the literature are summarized below.

Swain (*8*)[2] states that, in certain experiments with hydrocyanic acid gas, adult lady beetles (*Hippodamia convergens* Guer.) were used because it could be determined within a comparatively few hours after fumigation whether or not they were alive.

Smith (*7*), in reporting the result of cyanide fumigation of house number 17 for the control of bed bugs, states that the insects in the vials in the fumigated enclosure were all dead at the end of the exposure, while those in the vials outside were all alive.

Neifert and Garrison (*4*), in comparing the toxic action upon insects of certain other gases with that of hydrocyanic acid gas, indicate their method of determining the kill in the following sentence: "The observations were begun when the insects were removed from the fumigatorium, and continued up to the time the percentage of dead became constant for any two successive days." With reference to insects[3] treated with chloropicrin the statement is made that, on removal from the fumigatorium, "all the insects were apparently dead, and none of them revived during a period of several days."

Neifert *et. al.* (*5*), using several species of weevils and employing some one hundred compounds, indicate the interval between fumigation and examination in the following terms: "After standing for

[1]This paper was prepared in January, 1927.

[2]Italic numbers in parentheses refer to Literature Cited.

[3]*Tribolium ferrugineum* Fab., *Calandra oryza* L., and *Plodia interpunctella* Hbn.

twenty-four hours at room temperature (21° to 32°C.), the percentage of dead weevils was determined. (All specimens were examined after twenty-four hours, and also after forty-eight hours, to avoid reporting as dead those which might have been only stupefied)." These writers do not indicate whether any stupefaction was thus discovered.

Schenk (*6*) indicates the procedure employed with test lots of certain grain insects fumigated with hydrocyanic acid gas as follows: "The boxes were removed at the close of the fumigation. The insects were examined under a hand lens and any which exhibited signs of life were recorded as alive and discarded. A further examination was made at the end of a twenty-four hour period. Such insects as then showed signs of life were recorded as stupefied and the balance recorded as dead. This twenty-four hour period was chosen after it was found that results were no different than those observed at the end of a seven-day period." This writer has tabulated the percentages of stupefied insects.

Aside from a general failure of investigators to mention the length of time from fumigation to final examination, the above references show considerable variation among those recording their procedure in this regard. Thus, the methods vary from examination immediately after the close of the exposure to as much as forty-eight hours later, and, in one instance, the final count was not based upon a constant interval but upon constancy of the percentage of (*Tribolium ferrugineum* Fab., *Calandra oryza* L., and *Plodia interpunctella* Hbn.) dead. However, the writers believe the usual procedure to be characterized by allowing an interval of twenty-four hours between the end of the exposure and the final determination of effectiveness. Under such circumstances it is but natural that scant reference should be found to the power of revival of fumigated insects.

In the fall of 1924, investigation of the effectiveness of various fumigation methods employed by dried-fruit packers in California was undertaken. During the following winter the senior author discovered that some of the insects which appeared to be dead on the first day following fumigation subsequently became active. This finding indicated the likelihood of error attaching to results secured from examinations made twenty-four hours after treatment, and necessitated inquiry as to the most appropriate interval after fumigation for making the final count. Accordingly, fumigated insects were thereafter subjected to protracted examination. In this manner there have been assembled, incidental to the study of various fumigation operations, considerable data on revival and the length of time between treatment and the final count in relation to accuracy of results.

All results here recorded relate to the adult and larval stages of the saw-toothed grain beetle[4] and the Indian-meal moth,[5] respectively. The experiments presented include six fumigations of railway cars, seven of packing-plants, and two of other chambers. In all instances carbon disulphid was used, but in two of the car fumigations carbon dioxide was employed in conjunction with it.

Methods of Examination

The initial examination of fumigated insects was ordinarily made on the same date the exposure ended, this being termed the zero day. In such cases the examination was usually completed within three hours after treatment, and never exceeded five hours. At the first inspection the insects were removed from the cheese cloth bag, in which they had been fumigated with a small quantity of fruit, and placed in a pan for counting. The living individuals were then placed in one vial and supplied with uncontaminated fruit, while those exhibiting no evidence of life were similarly placed in another vial. The insects were always handled with camel's hair brushes. At later examinations the insects were removed from a vial to a pan for inspection. Adjustments between the two vials of a given test-lot were then made in accordance with changes which had now become evident; that is to say, individuals in the dead batch manifesting unmistakable signs of life were removed to the vial containing living individuals, while any in the latter vial which now appeared to be lifeless were transferred to the vial containing the apparently dead individuals. Records of all such exchanges were kept.

In such a work as this it is essential that a constant basis of differentiation be applied to each insect for the determination of life or apparent death. The distinction here used was based upon the necessity of observing some movement of the insect before life could be attributed to it. In the event of rapid revival to such a degree as to permit the locomotion normal to the particular stage of a species there was, of course, no need to resort to special tests for the determination of an individual's status. It so happens, however, that the first movements of reviving insects are often slight, sometimes necessitating the use of a hand lens as an aid to accurate decision. While there are other criteria as to the condition of an insect in its active stages, movement must be the ultimate gauge of its possession of life.

Doubtful adults of Oryzaephilus were tested by exhaling the breath upon them several times. The proximity of the mouth to the insects and

[4] *Oryzaephilus surinamensis* Linné, hereafter referred to as Oryzaephilus.
[5] *Plodia interpunctella* Hbn., hereafter referred to as Plodia.

the volume of breath was always sufficiently limited to prevent the condensation of moisture on the surface supporting the insects. The response of living beetles to this test was movement of the legs and antennae. The testing of doubtful Plodia larvae was somewhat more intricate. Here the thigmotropic response was more valuable. The well-known response of normal larvae to touch was approximated by fumigated larvae only in instances where the effect of the treatment had not been severe, or after the early stages of recovery had been passed. After lightly touching doubtful larvae at several points on the dorsum with the smooth, blunt butt-end of a camel's hair brush, the first movements were usually noticed in the head region and consisted of movements of the mouth-parts, the legs, or very slight movements of the head, either vertically or horizontally.

Before fumigation and during the period of protracted examination following fumigation the insects were kept at normally-fluctuating room temperature, it being believed that such handling minimized the influence of extraneous factors upon revival, such as would have obtained with retention of the fumigated insects at carefully-controlled uniform temperatures. The principal difference here involved was that before fumigation the insects were subject to the moderating effects of small masses of dried fruit, while after treatment they were confined in loosely-stoppered vials with only two or three raisins. This feature of the handling, as discussed elsewhere, was no doubt prejudicial to revival and therefore in favor of conservative results.

Because of the number of insects included in each experiment it was entirely impracticable to retain the revivals and subsequent deaths from each examination as separate units for further observations, despite the great desirability of so doing. Such handling would have been productive of two important results. First, the extent of ultimate survival would doubtless have been affected for it has often been observed that, even with untreated individuals, the percentage of mortality under crowded conditions is very considerably increased. Second, the retention of each day's revivals as separate units would have permitted calculation of the percentage of ultimate survival of those which revived, as well as a determination of their normalcy.

Counts of Fumigated Insects Over a Protracted Period

With the exception of the fumigations in the sulphur house and the trash fumigator, the following data are drawn from experiments conducted under commercial conditions. Since this paper has to do solely with the phenomenon of insect revival, the pertinent conditions are

merely outlined, with no attempt at discussion of the merits or demerits of the various operations. It should be stated, however, that the different lots of insects within a given experiment represent differently located batches of insects within the fumigated enclosure. Each of these lots was enclosed in a single thickness of cheese cloth and placed in the center of the specified unit of the lading or contents.

A. RAILWAY CAR FUMIGATION

EXPERIMENT I

Fumigation of	Railway car	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS_2	27.9£ 1000 c.f.		
Exposure	17 hrs., 45 min.	Temp. (Fahr.)	Start, 65; end, 49
Insect	Oryzaephilus adults	P.c.Rel.Hum.	Start, 66; end, 86
		Date	March 5–6, 1926

TABLE 1A. RECORD OF PROTRACTED COUNTS

Lot No.	Original count Condition	0 day	Nature of change	Subsequent changes Number of individuals changing status after— 1 day	2 ds.	3 ds.	4 ds.	5 ds.	6 ds.	7 ds.	8 ds.	9 ds.	10 ds.	11 ds.	12 ds.	13 ds.	14 ds.	Totals
1	Living	0	Deaths	0	1	4	2	0	5	0	9	5	4	5	2	2	7	46
	Dead	131	Revivals	7	26	7	8	7	12	0	1	2	3	3	0	0	0	76
2	Living	0	Deaths	0	9	3	3	6	7	4	1	8	4	0	3	3	1	52
	Dead	147	Revivals	133	12	0	0	4	5	3	0	2	2	0	0	0	0	161
3	Living	0	Deaths	0	0	2	4	4	2	6	6	6	6	7	3	1	8	55
	Dead	137	Revivals	9	49	11	13	6	6	3	1	0	0	0	1	0	0	99
4	Living	0	Deaths	0	3	2	0	5	2	4	5	10	5	6	8	5	4	59
	Dead	152	Revivals	19	47	15	19	16	1	2	0	1	3	0	0	0	0	123
5	Living	0	Deaths	0	0	3	5	14	6	9	7	13	5	5	14	5	7	93
	Dead	185	Revivals	49	70	31	14	1	3	2	3	1	0	0	0	0	0	174
6	Living	0	Deaths	0	2	5	4	4	3	9	9	5	10	5	2	2	0	60
	Dead	130	Revivals	51	44	14	4	4	0	1	1	0	0	0	0	0	0	119
7	Living	0	Deaths	0	0	0	1	1	1	3	0	3	2	4	4	5	2	26
	Dead	119	Revivals	0	8	1	6	7	0	9	7	1	5	0	0	0	0	44
To-	Living	0	Deaths	0	15	19	19	34	26	35	37	50	36	32	36	23	29	391
tals	Dead	1001	Revivals	268	256	79	64	45	27	20	13	7	13	3	1	0	0	796

Table 1A shows the numbers of living and apparently dead Oryzaephilus adults in each of the several test lots on the day the exposure ended, and presents a record of the daily changes in status over a 14-day period. Analysis of this table reveals, in the main, two opposing and overlapping trends. The totals show abundant revival, beginning early and diminishing rapidly. Indeed, this trend is largely restricted to the first week following fumigation. Subsequent death, on the other hand, builds up from a small beginning and extends over the entire period. Thus, for a time, revivals outnumber subsequent deaths; later, subsequent deaths are in the majority. The totals establish this change as taking place on the seventh day.

By virtue of the different locations of the several test lots, affecting the degree of exposure to the fumigant, deviations from the average trend are to be expected. Nevertheless, examination of the records of individual lots shows a general coincidence with the average trend just noted, lots 2 and 7 being the exceptions. In lot 2, revival on the first day was so nearly complete as to leave few beetles for later revival, thus operating to establish the excess of subsequent death over revival on the third day. Lot 7 was characterized by light, prolonged revival. Permanent excess of subsequent death over revival obtained on the eleventh day. These conditions, together with the ultimate excess of revivals over subsequent deaths, clearly indicate that lot 2 received an exceptionally small amount of the fumigant, while lot 7 was subjected to a concentration greater than the average.

TABLE 1B. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Lot No.	Number insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days	13 days	14 days
1	131	100	94.7	75.6	73.3	68.7	63.4	58.0	58.0	64.1	66.4	67.2	68.7	70.2	71.8	77.1
2	147	100	9.5	7.5	9.5	11.6	12.9	14.3	15.0	15.6	19.7	21.1	21.1	23.1	25.2	25.8
3	137	100	93.4	57.7	51.1	44.5	43.1	40.1	42.3	46.0	50.4	54.7	59.8	61.3	62.0	67.9
4	152	100	87.5	58.5	50.0	37.8	30.4	30.9	32.2	35.7	41.4	42.8	46.7	52.0	55.3	57.9
5	185	100	73.3	35.7	20.5	15.7	22.7	24.3	28.1	30.3	36.8	39.5	42.2	49.7	52.4	56.2
6	130	100	60.8	28.5	21.5	21.5	21.5	23.8	30.0	36.1	40.0	47.7	51.5	53.1	54.6	54.6
7	119	100	100.0	93.3	92.4	88.2	83.2	84.0	78.9	73.1	74.8	72.2	75.5	78.9	83.2	85.0
Total & Avg.	1001	100	73.2	49.2	43.2	38.7	37.6	37.5	39.0	41.4	45.7	48.0	50.9	54.4	56.6	59.6

Each disparity between revivals and subsequent deaths affects the percentage of calculated kill. Table 1B presents, in percentages, the resultant of the two trends recorded numerically in Table 1A. The average per cent of kill declines from 100% on the zero day to a minimum of 37.5% on the sixth day, then rises again to a final kill of 59.6% on the fourteenth day after fumigation. Were this curve plotted it would consist roughly of three portions. The sharp initial descent and the gradual terminal ascent would be separated by a comparatively horizontal interval from the fourth to the seventh day. This 4-day period represents a period of comparative inactivity or balanced activity between the two separate trends observed in Table 1A.

The importance of the interval between fumigation and examination is obvious. Had the final inspection been made 24 hours after fumigation the recorded kill would have been 35.7% higher than it was six days after treatment, and 13.6% greater than it was on the fourteenth day following fumigation.

EXPERIMENT II

Fumigation of	Railway car	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS,	41.8£ 1000 c.f.		
Exposure	24 hrs, 30 min.	Temp. (Fahr.)	Start, 64; end, 68
Insects	(a) Oryzaephilus adults	P.c.Rel.Hum.	Start, 51; end, 51
	(b) Plodia larvae (grown)	Date	March 11–12, 1926

TABLE 2A. RECORD OF PROTRACTED COUNTS

(a) Oryzaephilus adults

Lot No.	Original count Condition	0 day	Nature of change	Subsequent changes Number of individuals changing status after— 1 day	2 ds.	3 ds.	4 ds.	5 ds.	6 ds.	7 ds.	8 ds.	9 ds.	10 ds.	11 ds.	12 ds.	Totals	No. moths issued	Per cent emergence
1	Living	0	Deaths	0	0	2	3	2	3	6	9	19	20	8	5	77		
	Dead	142	Revivals	0	29	33	56	5	0	0	0	0	0	0	0	123		
2	Living	0	Deaths	0	0	5	10	1	4	8	8	20	10	8	8	82		
	Dead	151	Revivals	18	48	18	14	3	0	0	0	1	0	0	0	142		
3	Living	0	Deaths	0	0	2	0	4	5	4	3	5	3	3	1	30		
	Dead	139	Revivals	28	66	18	0	0	0	0	0	0	0	0	0	112		
4	Living	0	Deaths	0	0	0	3	3	7	10	11	12	12	14	5	77		
	Dead	110	Revivals	0	23	30	41	0	0	0	0	0	0	0	1	95		
5	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Dead	101	Revivals	0	0	0	0	0	0	0	0	0	0	0	0	0		
6	Living	0	Deaths	0	0	0	1	5	5	6	19	32	12	2	18	93		
	Dead	149	Revivals	6	8	35	64	3	0	0	0	3	1	0	0	120		
7	Living	0	Deaths	0	0	5	6	4	8	7	6	14	1	7	2	60		
	Dead	114	Revivals	10	17	34	27	3	0	0	0	0	0	0	1	92		
8	Living	0	Deaths	0	0	3	5	14	7	12	7	11	13	0	4	76		
	Dead	128	Revivals	7	20	39	30	2	0	0	0	2	0	0	0	100		
9	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Dead	95	Revivals	0	0	0	0	0	0	0	0	0	0	0	0	0		
Tot.	Living	0	Deaths	0	0	17	28	33	39	53	56	113	71	42	43	495		
& Av.	Dead	1129	Revivals	69	211	247	232	16	0	0	0	6	1	0	2	784		

(b) Plodia larvae

Lot No.				Number of individuals changing status after— 1 d.	2 d.	3 d.	4 d.	5 d.	6 d.	7 d.	8 d.	9 d.	10 d.	11 d.	12 d.	15 d.	17 d.	18 d.	20 d.	21 d.	24 d.	25 d.			
1	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Dead	7	Revivals	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	2	100
2	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	3		
	Dead	7	Revivals	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	4	1	25
3	Living	0	Deaths	0	0	p	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1		
	Dead	7	Revivals	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	75
4	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1		
	Dead	6	Revivals	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	0	1
5	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Dead	9	Revivals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	—
6	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1		
	Dead	10	Revivals	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1	50
7	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2		
	Dead	6	Revivals	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	3	1	33
8	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1		
	Dead	10	Revivals	0	0	0	0	0	1	0	1	0	3	0	0	0	0	0	0	0	0	0	5	0	0
9	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1		
	Dead	10	Revivals	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Tot.	Living	0	Deaths	0	0	0	0	0	0	0	0	0	0	1	0	0	3	1	3	0	1	1	10		
& Av.	Dead	72	Revivals	0	0	0	1	2	5	0	2	5	3	3	2	0	0	0	0	0	0	0	23	8	35

TABLE 2B. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

(a) Oryzaephilus adults (b) Plodia larvae

	Insect	Lot	No. insects	Per cent kill after—																			
		No.	used	0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days	15 days	17 days	18 days	20 days	21 days	24 days	25 days
		1	142	100.0	100.0	79.6	57.7	20.4	18.3	20.4	24.6	31.0	44.3	58.4	64.0	67.6							
		2	151	100.0	88.1	56.3	21.2	18.5	17.2	19.9	25.2	30.5	43.0	49.7	55.0	60.3							
		3	139	100.0	70.9	32.4	20.9	20.9	23.7	27.3	30.2	32.4	36.0	38.1	40.3	41.0							
		4	110	100.0	100.0	79.1	51.8	17.3	20.0	26.4	35.5	45.5	51.8	62.7	75.5	79.1							
	(a)	5	101	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							
		6	149	100.0	96.0	90.6	67.1	24.8	26.2	29.5	33.6	41.6	61.1	68.5	69.8	81.9							
		7	114	100.0	91.2	76.3	50.1	32.5	33.3	40.4	46.5	51.8	64.0	64.9	71.1	71.9							
		8	128	100.0	94.5	78.9	50.8	31.3	40.6	46.1	55.5	60.9	68.0	78.1	78.1	81.3							
		9	95	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							
	Tot. & Avg.		1129	100.0	93.9	75.2	54.8	36.8	38.3	41.7	46.4	51.4	60.4	66.6	70.3	74.0							
		1	7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	85.7	85.7	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4
		2	7	100.0	100.0	100.0	100.0	100.0	100.0	71.4	71.4	71.4	42.8	42.8	57.1	57.1	57.1	57.1	85.7	85.7	85.7	85.7	85.7
		3	7	100.0	100.0	100.0	100.0	85.7	57.1	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	42.8	57.1	57.1	57.1	57.1
		4	6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	83.3	66.7	66.7	66.7	83.3	83.3	83.3	83.3	83.3	83.3
	(b)	5	9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		6	10	100.0	100.0	100.0	100.0	100.0	100.0	90.0	90.0	90.0	90.0	90.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
		7	6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	83.3	83.3	83.3	66.7	50.0	50.0	66.7	66.7	66.7	66.7	83.3	83.3
		8	10	100.0	100.0	100.0	100.0	100.0	100.0	90.0	90.0	80.0	80.0	50.0	50.0	50.0	50.0	50.0	60.0	60.0	60.0	60.0	60.0
		9	10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	100.0	100.0	100.0	100.0
	Tot. & Avg.		72	100.0	100.0	100.0	100.0	98.6	95.8	88.9	88.9	86.1	79.2	75.0	72.2	69.4	69.4	73.6	75.0	79.2	79.2	80.6	81.9

The protracted count of Oryzaephilus adults presented in Table 2A roughly parallels the general trend of the preceding experiment, but the average level of kill is here higher, this being due to the presence of two lots showing perfect kills throughout the period of observation. With the exception of these two lots, revivals outnumbered subsequent deaths in each instance; in the totals, revivals exceeded the subsequent deaths by more than half. Thus, as shown in Table 2B, for Oryzaephilus we have an average kill of 100% on the zero day ranging downward to 36.8% on the fourth day, and attaining 74% on the twelfth day. It is also noteworthy that the recorded kill twenty-four hours after treatment exceeded that determined four and twelve days after fumigation by approximately 57% and 20%, respectively.

With regard to Plodia larvae, reference to the numerical record of changes in Table 12A establishes the limits of revival as the fourth and twelfth days, with the maximum revival occurring from the eighth to the twelfth day. Lots 3 and 5 present the principal departures from the average trend, inasmuch as the revivals in the former were exceptionally early, while in the latter there were no revivals. Table 2B shows for Plodia 100% kill through the third day, diminishing to 69.4% which obtained from the twelfth to the fifteenth day, and gradually increasing to 81.9% on the twenty-fifth day. With this species we see that the kill recorded twenty-four hours after fumigation was approximately 30% greater than that obtaining from twelve to fifteen days after fumigation, and was some 18% in excess of the kill shown twenty-five days after treatment. It should also be noted that, by the method of Neifert and Garrison above quoted, a perfect average kill of these larvae would have been determined, showing that constancy of the percentage of dead for two successive days is not a reliable criterion for this species when fumigated with carbon disulphid.

Revived larvae were, in this experiment, retained to determine whether any of them would develop to the imaginal condition. The data at the extreme right in Table 2A show that of 23 revivals, 13 survived on the twenty-fifth day, and that 8 of these individuals subsequently issued as adults. Thus 35% of the total revivals, or 62% of those alive 25 days after fumigation, produced moths.

The most remarkable disclosure of this examination is the length of time after which some larvae revived. Lots 1, 4, and 9, for instance, showed no revivals until the ninth day after fumigation. Both of the revivals from lot 1 produced adults, but none issued from lots 4 and 9. Indeed, taking the experiment as a whole, approximately two-thirds of the revivals occurred more than a week after fumigation.

Bearing in mind the fact that similarly numbered lots of Oryzaephilus adults and Plodia larvae were situated side by side during the fumigation, it is most interesting to note the difference in the revival phenomena of the two species. The lowest levels of average kill obtain on the fourth to fifth day and the twelfth to fifteenth day, respectively, for Oryzaephilus and Plodia. Despite the different reactions of the two species, a comparison of analagous lots reveals certain similarities. For instance, lots 5 and 9 of Plodia present close approximations to similarly numbered lots of Oryzaephilus showing perfect kills, for, although one larva revived in lot 9, it succumbed before the end of the detailed examination. Again, lot 3 is, in both cases, characterized by exceptionally early revival and by the lowest percentage of kill in the experiment. Further, lots 1 and 4 of Oryzaephilus began reviving one day later than all others which showed revival; similarly, the first revivals of lots 1 and 4 of Plodia occurred at the maximum revival interval shown in this experiment.

Unfortunately, the protracted count of Experiment III was terminated prematurely by oversight, and the record extends only to the fifth day after fumigation. The results are presented because of a variation in the method here introduced. In order to ascertain the effect

EXPERIMENT III[6]

Fumigation of	Railway car	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS,	14.9£ 1000 c.f.		
Exposure	21 hrs., 30 min.	Temp. (Fahr.)	Start, 97; end, 88
Insect	Oryzaephilus adults	P.c.Rel.Hum.	Start, 60; end, 62
		Date	April 13–14, 1926

TABLE 3. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

		Per cent kill after—					
Lot No.	No. insects used	0 day	1 day	2 days	3 days	4 days	5 days
1	139	100	8.6	28.8	33.8	40.3	43.2
2	109	100	15.6	35.8	37.6	42.2	43.1
3	119	100	84.3	83.8	83.8	82.0	85.6
4	128	100	22.7	43.8	44.5	47.7	50.8
5	103	100	100.0	100.0	100.0	100.0	100.0
6	93	100	24.7	50.5	52.7	52.7	58.1
Total & Avg.	691	100	41.1	54.7	56.4	58.8	61.4
7	114	[1]		100.0	93.0	93.0	95.6
8	70	[1]		44.3	51.4	52.9	52.9
9	150	[1]		100.0	92.0	92.7	91.3
Total & Avg.	334	[1]		88.3	83.8	84.4	84.7

[1]Test-lot not removed from boxes of raisins until the second day after fumigation.

[6]By way of shortening this paper, the remaining results are shown only in terms of per cent kill, this, as above noted, representing the resultant of the two trends of revival and subsequent death.

upon revival of leaving the test lots longer in the boxes of fumigated fruit, three of these were not removed until the second day after fumigation.

The average of the first part of this experiment shows the maximum revival to have occurred on the first day following fumigation, with a steady increase in the percentage of mortality thereafter. The average of the second portion also shows the maximum revival on the next day after removal of the lots from the fumigated boxes of fruit; that is, on the third day after fumigation. Despite the fact that the level of kill is higher in the portion remaining longer in the boxes, no conclusion as to the effect of the delayed removal upon mortality is warranted in view of the fact that in Experiment 2, where the corresponding lot numbers represent similar locations in both experiments, the average of the last three lots is likewise higher than that of the remainder.

EXPERIMENT IV

Fumigation of	Railway car	Lading	Boxes packed with 3 dozen 15-oz. cartons each; cartons without paper liners.
Charge of CS_2	10.94£ 1000 c.f.		
CO_2	5.06£ 1000 c.f.	Temp. (Fahr.)	Start, 92; end, 118
Exposure	6 hrs., 5 min.	P.c.Rel.Hum.	Start, 25; end, 9[1]
Insect	Oryzaephilus adults	Date	August 5, 1925

TABLE 4. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Lot No.	No. insects used	Per cent kill after—				
		1 day	3 days	5 days	7 days	10 days
1	110	82.7	87.3	90.0	94.5	97.3
2	191	14.1	55.0	57.1	62.3	63.3
3	204	99.5	97.1	97.1	97.1	98.5
4	185	100.0	100.0	100.0	100.0	100.0
Total & Avg.	690	73.3	84.6	85.7	87.8	89.0

[1]Rel. Hum. percentages taken from Weather Bureau Office records for noon and 5:00 p. m., respectively.

Experiment 4, in contrast to the preceding ones, presents a constant upward trend of the average kill from the first to the tenth day after fumigation. A total of ten revivals occurred, all by the third day; two of the revived beetles in lot 3 survived beyond the tenth day.

EXPERIMENT V

Fumigation of	Railway car	Lading	Boxes packed with 3 dozen 15-oz. cartons each; cartons without paper liners.
Charge of CS_2	19.23£ 1000 c.f.		
CO_2	5.09£ 1000 c.f.	Temp. (Fahr.)	Start, 92; end, 118
Exposure	5 hrs., 45 min.	P.c.Rel.Hum.	Start, 25; end, 9[1]
Insect	Oryzaephilus adults	Date	August 5, 1925

TABLE 5. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Lot No.	No. insects used	Per cent kill after—				
		1 day	3 days	5 days	7 days	10 days
1	172	3.5	12.3	14.0	15.1	17.4
2	209	100.0	100.0	100.0	100.0	100.0
3	195	4.8	18.2	19.1	20.1	21.1
4	183	100.0	100.0	100.0	100.0	100.0
Total & Avg.	759	51.9	57.6	58.2	58.8	59.6

[1]Rel. Hum. percentages taken from Weather Bureau Office records for noon and 5:00 p. m., respectively.

Table 5 shows all subsequent changes to have occurred in lots 1 and 2, where the very small original kills gradually increased to approximately 20% on the tenth day. Only 1 revival was recorded.

EXPERIMENT VI

Fumigation of	Railway car, papered interiorly	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS_2	30.4£ 1000 c.f.	Temp. (Fahr.)	Start, 88; end, 79
Exposure	18 hrs., 30 min.	P.c.Rel.Hum.	Start, 42; end, 40
Insect	Oryzaephilus adults	Date	June 11–12, 1926

TABLE 6. PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Lot No.	No. insects used	Per cent kill after—									
		0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days
1	146	100	100	100	100	100	100	100	100	100	100
2	138	100	100	100	100	100	100	100	100	100	100
3	112	100	100	100	100	100	100	100	100	100	100
4	111	100	100	100	100	100	100	100	100	100	100
5	82	100	100	100	100	100	100	100	100	100	100
6	106	100	100	100	100	100	100	100	100	100	100
Tot. & Avg.	695	100	100	100	100	100	100	100	100	100	100
7	126	[1]		100	100	100	100	100	100	100	100
8	116	[1]		100	100	100	100	100	100	100	100
9	115	[1]		100	100	100	100	100	100	100	100
Tot. & Avg.	357	[1]		100	100	100	100	100	100	100	100

[1]Test-lot not removed from box of raisins until second day after fumigation.

Table 6 shows a perfect kill with no revivals. Since this applies both to the lots removed from fumigated boxes at the end of the exposure as well as to those removed therefrom two days later, the im-

Experiment VII

Fumigation of	Sulphur House (Brick and Cement)	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS_2	22.9£ 1000 c.f.		
Exposure	25 hrs.	Temp. (Fahr.)	Start, 63; end, 63
Insects	(a) Oryzaephilus adults	P.c.Rel.Hum.	Start, 51; end, 51
	(b) Plodia larvae (grown)	Date	March 11–12, 1926

Table 7. Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Insect	Lot No.	No. insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days	15 days	17 days	18 days	20 days	21 days	24 days	25 days
	1	142	100.0	13.4	2.8	4.2	6.3	7.0	7.7	8.5	9.9	11.3	12.0	14.8	14.8							
(a)	2	135	100.0	92.6	80.0	55.5	47.4	43.7	48.9	55.5	61.5	71.9	83.0	92.6	95.1							
	3	117	100.0	94.0	64.1	56.4	23.9	27.4	28.2	31.6	37.6	44.4	48.7	48.7	50.4							
Tot. & Avg.		394	100.0	64.5	47.5	37.3	25.6	25.6	27.9	31.5	35.8	41.9	47.2	51.5	53.3							
	1	5	100.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
(b)	2	10	100.0	100.0	100.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	50.0	30.0	30.0	30.0	30.0	30.0	40.0	40.0
	3	9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	78.0	78.0	78.0	67.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0
Tot. & Avg.		24	100.0	87.0	87.0	71.0	67.0	71.0	71.0	71.0	62.0	62.0	62.0	58.0	46.0	37.0	37.0	37.0	37.0	37.0	42.0	42.0

portance of the time of removal of the lots from fumigated packages appears to be slight.

B. SULPHUR-HOUSE FUMIGATION

Only one experiment attaches to this category. The results, as embodied in Table 7, present a general coincidence with the results of Experiment 2, as shown in Table 2B. Both experiments were made on the same dates. The correspondingly numbered lots of the two species used in this experiment were fumigated side by side.

Here, again, we find revival and subsequent death operating to establish varying percentages of mortality throughout the protracted examination. In the case of the Oryzaephilus average, revival depresses the initial perfect kill to a minimum of 25.6% on the fourth day; during the succeeding eight days subsequent death elevates the kill to 53.3% on the twelfth day. Thus, the kill revealed one day after treatment was approximately 39% greater than that determined on the fourth (or fifth) day, and also exceeded the percentage of dead recorded twelve days after fumigation by approximately 11%.

With Plodia revival was slower; the original average kill of 100% diminished to 37% from the fifteenth to the twenty-first day, and reached 42% twenty-five days after fumigation. In this case the effectiveness determined one day after treatment exceeded by 50% and 45%, respectively, the percentages of dead which obtained fifteen (to twenty-one) and twenty-five days after fumigation. It is also clear that, by the method of selecting the percentage of dead which was constant for two successive days, perfect kills would have been recorded for lots 2 and 3, whereas the percentages of dead after twenty-five days were 40% and 44%, respectively.

The revival of the Plodia lots is most interesting. It will be observed that the earliness of revival varied greatly in the three lots. The total revivals in lot 1 occurred on the first day; in lot 2 the first revivals occurred on the third day, with others reviving between the twelfth and the fifteenth day; finally, in lot 3, revival began on the eighth day and was again operative on the eleventh and the twelfth day. Lots 1, 2, and 3 were located at the top, middle, and bottom, respectively, of the sulphur-house. It thus appears that the carbon disulphid gas, in the absence of agitation assumed a greater density toward the bottom and that this density is directly correlated with the tardiness of revival. However, little effect upon the extent of revival is attributable to such a stratification of the fumigant. Moreover, the survival after

Experiment VIII

Fumigation of	Trash Fumigator	Lading	25-lb. boxes bulk raisins, with glasine paper liners
Charge of CS_2	21.8 £ 1000 c.f.		
Exposure	24 hrs.	Temp. (Fahr.)	Start, 58; end, 60
Insects	(a) Oryzaephilus adults	P.c.Rel.Hum.	Start, 69; end, 83[1]
	(b) Plodia larvae (grown)	Date	February 3–4, 1926

Table 8. Average Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Insect	No. of test-lots used	No. insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days	13 days	14 days	15 days	16 days	17 days	18 days
(a)	3	146	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(b)	3	29	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Rel. Hum. percentages taken from Weather Bureau records for the noon periods of the two days.

twenty-five days gives no indication that it is influenced by the time of revival.

C. FUMIGATION IN TRASH FUMIGATOR

One experiment was performed in this type of chamber. The interior lining of felt roofing minimized the leakage factor. Evaporation of the carbon disulphid was promoted by saturating gunny sacks with it and suspending them from the top of the chamber. The kill of both Oryzaephilus and Plodia was perfect and there were no revivals, as shown in Table 8.

D. PACKING-PLANT FUMIGATION

The percentages of kill of Oryzaephilus and Plodia in Experiment 9, as set down in Table 9, again reflect the prolonged influence of revival and subsequent death.

Two of the Oryzaephilus lots show perfect kills throughout the period of examination. From lot 5, one beetle, which revived by the third day, survived on the twenty-first day. In lots 2, 3, and 4 sharp reductions in the percentages of apparent mortality occurred during the first three days, while counts on the fifth day and subsequent thereto showed gradual increases in the percentages of dead. With respect to these three lots it is noteworthy that the percentage of dead on the final day in no case attained the initial figure, but represented points intermediate between the counts of the zero and the third day. Thus it is certain that approximately one-third of the revived beetles still survived three weeks after fumigation.

This is the only experiment in which the Oryzaephilus counts were extended over three weeks, and it is interesting to note the trivial nature of the changes which occurred during the third week.

No Plodia larvae revived during the first week after fumigation, and the greatest number of revivals was recorded on the ninth and the eleventh day. Thus, constancy of the percentage of dead for two, or even seven, successive days would not have provided an accurate indication of effectiveness. The maximum revival had been attained by the fifteenth day, when the average kill was 61.6%. Thereafter, subsequent deaths operated to establish a kill of 69.6% on the twenty-fifth day after fumigation.

This experiment permits no comparison of the 24-hour method with protracted examination since no count was made on the first day after fumigation.

In this experiment the examination of Plodia revivals extended

Experiment IX

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.9 £ 1000 c.f.	Temp. (Fahr.)	Start, 73; end —
Exposure	36 hrs.	P.c.Rel.Hum.	Start, 37; end —
Insects	(a) Oryzaephilus adults (b) Plodia larvae (grown)	Date	October 10–12, 1925

Table 9. Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Insect	Lot No.	No. insects used	Per cent kill after— 0 days	3 days	5 days	7 days	9 days	11 days	13 days	15 days	17 days	19 days	21 days	23 days	25 days	95 days	130 days	144 days	156 days	173 days
	1	126	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							
	2	117	88.9	62.4	75.2	77.8	79.5	81.2	82.1	82.1	82.1	82.1	82.1							
(a)	3	85	91.8	51.8	63.5	75.3	77.6	77.6	80.0	80.0	83.5	83.5	83.5							
	4	104	94.2	73.1	74.0	79.8	79.8	81.7	81.7	81.7	81.7	81.7	81.7							
	5	97	100.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0							
	6	108	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							
Tot. & Avg.		637	95.9	82.1	86.2	89.2	89.8	90.4	90.9	90.9	91.4	91.4	91.4							
	1	25	100.0	100.0	100.0	100.0	100.0	100.0	96.0	68.0	72.0	84.0	88.0	88.0	88.0	88.0	92.0	96.0	100.0	——
	2	25	100.0	100.0	100.0	100.0	100.0	84.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	64.0	64.0	68.0	84.0	100.0
(b)	3	25	100.0	100.0	100.0	100.0	60.0	56.0	56.0	56.0	56.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	84.0	[1]
	4	25	100.0	100.0	100.0	100.0	64.0	56.0	60.0	60.0	60.0	64.0	64.0	64.0	64.0	68.0	72.0	80.0	100.0	——
	5	25	100.0	100.0	100.0	100.0	100.0	68.0	72.0	72.0	72.0	80.0	80.0	80.0	80.0	92.0	96.0	100.0	——	——
Tot. & Avg.		125	100.0	100.0	100.0	100.0	84.3	72.8	68.0	61.6	63.2	68.8	69.6	69.6	69.6	74.4	76.8	80.8	93.6	96.8

[1]This container was discarded by mistake.

approximately five months beyond the usual twenty-five day period. Although comparatively few of the larvae died during the first four months of this additional period, practically all succumbed during the fifth month. These larvae fed little and, while most of them died as larvae, several pupated successfully. It is noteworthy that all of these apparently normal pupae gradually became shriveled and discolored, and none of them produced adults. The loss of the container with the four larvae which survived 173 days after fumigation is most unfortunate, although it seems probable that they too would have died. These results are very different from those of Experiment 2 where some revived larvae later issued as adults. The writers are inclined to attribute this difference to the fact that that experiment was conducted in the spring while this one was performed in the fall. Thus the larvae, after revival in this experiment, were subject to a prolonged period of unfavorable weather while those of Experiment 2 were soon subject to conditions suitable for their further development.

This experiment, in common with number 7, provides no indication of a correlation between the time of revival and the proportion of survival. Thus, in the lots (3 and 4) showing the earliest revivals, being on the ninth day, approximately one-third of the revivals subsequently died. From lots 1 and 5, which started reviving on the thirteenth and eleventh day, respectively, approximately two-thirds of the revivals died. However, in lot 2 the revivals were also delayed until the eleventh day, but here only one-ninth of them had died by the twenty-fifth day.

EXPERIMENT X

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.76£ 1000 c.f.		
Exposure	25 hrs., 15 min.	Temp. (Fahr.)	Start, 83; end, 88
Insects	(a) Oryzaephilus adults	P.c.Rel.Hum.	Start, 29; end, 37
	(b) Plodia larvae (grown)	Date	June 27–28, 1926.

TABLE 10. AVERAGE PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Insect	No. of test-lots used	No. insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days
(a)	6	686	100	100	100	100	100	100	100	100	100	100	100
(b)	6	90	100	100	100	100	100	100	100	100	100	100	100

Tables 10 and 11 show the average percentages of kill of both Oryzaephilus and Plodia to have been perfect. There were no revivals. The Plodia larvae were not checked longer than ten days because of

EXPERIMENT XI

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.47£ 1000 c.f.		
Exposure	25 hrs., 15 min.	Temp. (Fahr.)	Start, 85; end, 88
Insects	(a) Oryzaephilus adults	P.c.Rel.Hum.	Start, 44; end, 37
	(b) Plodia larvae (grown)	Date	June 27–28, 1926

TABLE 11. AVERAGE PER CENT KILL AS SHOWN BY EXAMINATIONS AT DIFFERENT INTERVALS AFTER FUMIGATION

Insect	No. of test-lots used	No. insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days
(a)	6	717	100	100	100	100	100	100	100	100	100	100	100
(b)	6	90	100	100	100	100	100	100	100	100	100	100	100

their brown color and dried, shriveled condition, indicating certain death.

Table 12, presenting the results of this experiment, shows that no revivals occurred. Three lots yielded perfect kills throughout the examination. The other three showed gradual increases in mortality to the seventh day; thereafter no changes occurred.

Three revivals occurred in this experiment, but, as shown in Table 13, the results otherwise closely parallel those of the preceding experiment.

Table 14 shows that the kill in this experiment, even as determined on the zero day, was considerably short of 100%. It is noteworthy that here, with the exception of lot 6, the revival occurred early, establishing the average percentage of minimum kill on the sixth day, whereas in other experiments presented above the major revival did not occur until after the first week. This earliness of revival indicates a very imperfect fumigation, and this is further supported by the great extent to which revival proceeded. Attention is directed to the decline of the average percentage of effectiveness from 64.8% on the zero day to 26.9% on the sixth day, and the subsequent increase to 31.9% on the twenty-fifth day. By the thirty-fifth day the mortality had increased to 43.1%. Thus, by a final count made one day after fumigation the average effectiveness would have exceeded by approximately 34% and 18%, respectively, the mortality determined six and thirty-five days after fumigation.

The results of this experiment, embodied in Table 15, are rather similar to those of the preceding experiment. In two lots complete revival obtained for a time. The percentage of average kill on the zero day was 85.8%; on the sixth day, 22.3%; on the twenty-fifth day, 35.2%; and on the thirty-fifth day, 38.6%. Thus, the percentage of kill re-

Experiment XII

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.76£ 1000 c.f.	Temp. (Fahr.)	Start, 92; end, 71
Exposure	37 hrs., 30 min.	P.c.Rel.Hum.	Start, 32; end, 23
Insect	Oryzaephilus adults	Date	August 14–16, 1926

Table 12. Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Lot No.	No. insects used	Per cent kill after—											
		0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days
1	42	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	40	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	33	78.8	81.8	81.8	87.9	87.9	93.9	93.9	97.0	97.0	97.0	97.0	97.0	97.0
4	36	86.1	86.1	88.9	88.9	94.4	97.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	53	71.7	75.5	75.5	75.5	84.9	92.5	92.5	96.2	96.2	96.2	96.2	96.2	96.2
6	46	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Tot. & Avg.	250	89.2	90.4	90.8	91.6	94.4	97.2	97.6	98.8	98.8	98.8	98.8	98.8	98.8

Experiment XIII

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.47£ 1000 c.f.	Temp. (Fahr.)	Start, 89; end, 73
Exposure	37 hrs., 30 min.	P.c.Rel.Hum.	Start, 36; end, 42
Insect	Oryzaephilus adults	Date	August 14–16, 1926

Table 13. Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Lot No.	No. insects used	Per cent kill after—												
		0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days
1	43	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	54	96.3	92.6	92.6	94.4	96.3	96.3	96.3	96.3	96.3	98.1	98.1	98.1	98.1
3	40	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	51	78.4	76.5	88.2	92.2	92.2	96.1	98.0	100.0	100.0	100.0	100.0	100.0	100.0
5	32	88.4	84.4	87.5	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	52	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Tot. & Avg.	272	93.4	92.3	94.9	97.1	97.8	98.5	98.9	99.3	99.3	96.6	99.6	99.6	99.6

Experiment XIV

Fumigation of	Packing Plant	Contents	Stored figs in stacked picking boxes
Charge of CS_2	2.47£ 1000 c.f.	Temp. (Fahr.)	Start, 65; end, 54
Exposure	39 hrs., 45 min.	P.c.Rel.Hum.	Start, 48; end, 53
Insect	Plodia larvae (grown)	Date	November 6–8, 1926

Table 14. Per Cent Kill as Shown by Examinations at Different Intervals After Fumigation

Lot No.	No. insects used	Per cent kill after— 0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days	13 days	14 days	15 days	17 days	19 days	21 days	25 days	35 days
1	25	96.0	96.0	72.0	24.0	28.0	28.0	28.0	28.0	24.0	24.0	24.0	28.0	24.0	24.0	24.0	24.0	24.0	28.0	32.0	32.0	44.0
2	25	24.0	24.0	16.0	12.0	8.0	8.0	8.0	8.3	8.3	8.3	8.3	8.3	8.3	8.3	20.8	20.8	20.8	20.8	20.8	20.8	33.3
3	25	28.0	8.0	8.0	4.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	16.0
4	25	76.0	76.0	44.0	20.0	16.0	16.0	12.0	12.0	16.0	20.0	20.0	20.0	20.0	20.0	20.0	16.0	16.0	16.0	16.0	16.0	36.0
5	25	72.0	72.0	48.0	20.0	32.0	36.0	20.0	32.0	28.0	28.0	24.0	24.0	24.0	24.0	28.0	28.0	28.0	28.0	28.0	28.0	40.0
6	20[1]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0	95.0	90.0	90.0	90.0	90.0	90.0	100.0	100.0	100.0	100.0
Tot & Avg.	145	64.8	61.4	46.2	27.6	29.7	30.3	26.9	29.2	28.5	29.2	27.8	28.5	27.1	27.1	29.9	29.2	29.2	31.3	31.9	31.9	43.1

[1]Five larvae were here found mashed and have been deducted. Note: Lot 2, 7th day, 1 larva mashed; deducted.

																						20

vealed one day after treatment was 48% greater than that observed six days after fumigation. Furthermore, five weeks after fumigation there were approximately 32% more larvae alive than appeared to be so one day after treatment.

Discussion

The Influence of Temperature on Revival

Mention by recent writers of the important influence of temperature on the effectiveness of carbon disulphid fumigation is well-nigh universal. Both Dean (*1*) and Hinds (*3*), in different ways, have emphasized this point. Both of these writers indicate that, in practical work, operations at temperatures below 60°F. are unsatisfactory. Girault (*2*), on the other hand, reported effective use of carbon disulphid at all temperatures, and stressed the point that failures in practical work are mostly attributable to serious loss of the vapor by leakage. None of these investigators referred to revival of treated insects, nor indicated the interval between fumigation and final examination of the insects as employed in experimental work.

While our immediate concern relates to revival and the length of time between treatment and examination, the bearing of the present data upon the temperature and leakage factors as above cited is of incidental interest.

The revival of Oryzaephilus and Plodia is a manifestation of imperfect fumigation wherein, however, the surviving individuals are, for a greater or lesser period, indistinguishable from the dead. That this reaction is definitely associated with moderately low temperatures is clearly shown by Table 16. Here the totals and averages of the preceding experiments pertaining to each species have been divided into two groups on the basis of the maximum temperature of fumigation. With each species the first group consists of experiments conducted under outside temperature maxima of 78°F. or lower; the second group, 81°F. or above.

The arrangement in Table 16 shows a striking contrast between the two divisions of each species, revealed both by the number of subsequent changes and by the average per cent kill at selected intervals. In the case of Oryzaephilus, with the exception of experiments in which perfect kills obtained throughout, the group influenced by the lower temperatures shows a constant excess of revivals over subsequent deaths; combining all experiments, the totals are approximately in the ratio of two to one. Excepting Experiment III, which may not properly be

TABLE 16. TOTALS AND AVERAGES OF EXPERIMENTS GROUPED ACCORDING TO TEMPERATURE: SHOWING RATIO OF REVIVALS TO SUBSEQUENT DEATHS AND THE COMPARATIVE TRENDS OF AVERAGE PERCENTAGES OF KILL OF (a) ORYZAEPHILUS ADULTS (b) PLODIA LARVAE (GROWN)

Expt. No.	Charge of CS$_2$ per 1000 c. f.	Exposure hrs.	Exposure min.	Temp. (Fahr.) Inside chamber At start	Temp. (Fahr.) Inside chamber At end	Temp. (Fahr.) Outside Max.	Per cent Rel. Hum. At start	Per cent Rel. Hum. At end	No. of insects used	Number of subsequent changes Revivals	Number of subsequent changes Sub. deaths	Average per cent kill at selected intervals after fumigation: Early examination Days	Early examination % kill	1st intermediate examination Days	1st intermediate examination % kill	2nd intermediate examination Days	2nd intermediate examination % kill	Final examination Days	Final examination % kill
(a) Oryzaephilus adults																			
1	27.9	17	45	65	49	69	66	86	1001	796	391	1	73.2	5	37.6			14	59.6
2	41.8	24	30	64	68	70	51	51	1129	784	495	1	93.9	5	38.3			12	74.0
7	22.9	25	00	63	63	63[1]	51	51	394	329	145	1	64.5	5	25.6			12	53.3
8	21.8	24	00	58	60	60	69	83	146	0	0	1	100.0	5	100.0			14	100.0
9	2.9	36	00	73	—	75	37	—	637	96	67	0	95.9	5	86.2			15	90.9
3	14.9	21	30	77	76	81	60	62	691	475	215	1	41.1	5	61.4				
4	10.94	6	05	92	118	104	25	9	690	10	118	1	73.3	5	85.7			10	89.0
5	19.23	6	45	92	118	104	25	9	759	1	59	1	51.9	5	58.2			10	59.6
6	30.4	18	30	88	79	96	42	40	695	0	0	1	100.0	5	100.0			9	100.0
10	2.76	25	15	83	88	107	29	37	686	0	0	1	100.0	5	100.0			10	100.0
11	2.47	25	15	85	88	107	44	37	717	0	0	1	100.0	5	100.0			10	100.0
12	2.76	37	30	92	71	103	32	23	250	0	24	1	90.4	5	97.2			12	98.8
13	2.47	37	30	89	73	103	36	42	272	3	20	1	92.3	5	98.5			12	99.6
(b) Plodia larvae																			
2	41.8	24	30	64	68	70	51	51	72	23	10	1	100.0	7	88.9	15	69.4	25	81.9
7	22.9	25	00	63	63	63[1]	51	51	24	16	2	1	87.0	7	71.0	15	37.0	25	42.0
8	21.8	24	00	58	60	60	69	83	29	0	0	1	100.0	7	100.0	12	100.0	18	100.0
9	2.9	36	00	73	—	75	37	—	125	63	25	0	100.0	7	100.0	15	61.6	25	69.6
14	2.47	39	45	65	54	78	48	53	145	67	19	1	61.4	7	29.2	15	29.2	25	31.9
15	3.18	39	45	65	54	78	51	53	148	104	25	1	70.3	7	25.0	15	28.8	25	35.2
10	2.76	25	15	83	88	107	29	37	90	0	0	1	100.0	7	100.0			10	100.0
11	2.47	25	15	85	88	107	44	37	90	0	0	1	100.0	7	100.0			10	100.0

[1]This was brick and concrete chamber inside packing plant, not subjected to sun's heat and little affected by outside temperature. The maximum temperature here is for the container and not for outside.

included in the comparison because of the exceptionally short period of examination, the converse is true of those experiments conducted at the higher temperatures, for the ratio of revivals to subsequent deaths is roughly one to sixteen.

The trends of mortality percentages in the two groups of Oryzaephilus experiments are also very different. In the lower-temperature group the percentages of mortality decrease sharply from the first to the fifth day, finally attaining levels intermediate between the extremes of the first and the fifth day. Experiment IX, of this group, was not counted on the first day, the zero-day count being nearest to it in point of time. In the higher-temperature group, on the other hand, the percentages, excepting those experiments marked by continued perfect kills, in all instances were larger at each successive examination.

The lower-temperature group of Plodia experiments shows the same general condition observed with Oryzaephilus, except that here the revival period is much longer. It will be noted that revivals outnumbered subsequent deaths roughly three to one. In general, the percentages of mortality decreased to the fifteenth day and subsequently increased, establishing on the twenty-fifth day levels intermediate between those of the first and the fifteenth day. The Plodia experiments of the higher-temperature division are too few to serve as a valid comparison with the other group. Indeed, the two experiments placed here were made during an extremely hot period when the maximum during the day was 107°F. and the minimum at night, 73°F.

While the association between revival and moderately low temperatures is obvious, it will be noted that in one experiment, the maximum temperature of which was 60°F., the kill of both Oryzaephilus and Plodia was perfect, and there were no revivals. This experiment, aside from having been performed under the lowest temperature here included, was conducted in a chamber of exceptional tightness. Thus, with the practical elimination of the leakage factor, revival was lacking despite the suitability of the temperature for such reaction. These circumstances indicate that although moderately low temperature is the primary condition favoring revival, insofar as temperatures above 60°F. are concerned, some imperfection of fumigation must contribute to the production of the revival phenomenon. In other words, the revival of these insects from the effects of carbon disulphid results from a combination of moderately low temperatures and one or more of the common imperfections of fumigation, such as leakage, inadequacy of the charge, insufficiency of the exposure, variation in the grade of carbon disulphid, penetration factor of the package, etc.

Since temperatures below 78°F. under natural conditions markedly affect both the insects and the fumigant, the immediate effect of such temperatures responsible for revival is obscure. In other words, is revival induced by the retarded metabolism of the insect or by the lessened activity of the fumigant resulting from the moderately low temperature? Both of these effects are important, but much investitation is necessary before their relative weight can be shown.

Methods of Determining Revival

The tests employed in determining revival involved very slight disturbance of the fumigated insects, as discussed above. However, even this degree of agitation does not ordinarily affect those insects left in the product after fumigation, and the question may be raised as to whether such disturbance was promotive of revival to a greater extent than would have obtained if left perfectly quiet and revival gauged by visual examination only.

Experience in handling the fumigated individuals under discussion provides no indications that revival is induced by disturbance of the character and extent here practiced. It is possible, however, that our method operated to reveal a slightly higher degree of revival than would have been shown by visual examination. For instance, it was noted that some Plodia larvae responded to touch very feebly for a few days, but died without any appreciable extension of the power of movement. Had such larvae been observed by eye only they might not have been recorded as having revived. Our method operated similarly with regard to Oryzaephilus adults. It should be added that revival of both species has been observed in the absence of any disturbance save that involved in the initial count as ordinarily made. Despite the possibility of our method yielding slightly higher extremes of revival as compared with revival obtaining among insects left undisturbed, there is no basis for believing that the extent of survival of revived individuals likewise would be augmented.

Subsequent Death

Subsequent death, as employed in this paper, covers both the delayed death of insects surviving fumigation, and the subsequent demise of revived individuals. In either case such deaths, as will have been noticed previously, have an important bearing upon the calculation of effectiveness of fumigation operations against Oryzaephilus and Plodia when employing carbon disulphid.

Some portion of the subsequent deaths doubtless represents indi-

viduals sufficiently impaired by the treatment so that ultimate recovery is impossible under any circumstances. It is believed, however, that a considerable percentage of such belated deaths, particularly in the case of Oryzaephilus because of the greater number used in experiments, is attributable to the confinement and crowding to which the insects were necessarily subjected during the protracted examination. A further factor, believed to have an especial bearing upon subsequent death in experiments conducted during summer, is the temperature to which the treated insects in vials were subject during the protracted examination. During summer in the San Joaquin Valley many objects indoors, including the vials containing the insects, are almost daily heated to 90°F., and they frequently attain temperatures between 95°F. and 100°F., while occasionally this temperature exceeds 105°F. Certainly one must concede that, were the surviving and reviving insects free to disperse and establish themselves in suitable locations, they would have far greater chance of ultimate recovery. If this reasoning be sound, the importance of insect revival is even greater than shown in certain of the experiments herein reviewed, for, whereas the effect of revival is partially counteracted by subsequent death due to the arbitrary handling of the test lots, a still greater proportion of the revivals among those insects naturally occurring in the fumigated product would ultimately survive.

Practical Importance of Revival

The point of practical value established by the above results relates to the necessity of extended examination of lots of insects planted in, or of individuals collected from, the treated product for the purpose of determining the effectiveness of fumigation operations with carbon disulphid. The unreliability of the 24-hour interval, or of a 48-hour period, for that matter, is clearly shown.

In general, the percentage of mortality is apt to fluctuate up or down subsequent to a brief interval following fumigation. In several experiments more living individuals were revealed by the final counts than by the examinations made twenty-four hours after treatment. Furthermore, it has been demonstrated that some of the revived Plodia larvae ultimately produced moths.

For Oryzaephilus adults the extreme interval between fumigation and revival encountered in this work was *ten days*. Those few individuals recorded as reviving at or near the end of the protracted examination have been excepted because they doubtless represent earlier revivals which were overlooked. Indeed, it is believed that the extreme interval

more correctly approximates seven days, due to the ever-present possibility of some artificial extension of the actual period of revival because of occasional mistaken assignment of living beetles to the dead batch, and the subsequent discovery that they were living. For Plodia the extreme revival interval was *fifteen* days. One larva which revived eleven days after fumigation later attained the imaginal condition.

The length of our protracted counts was determined by the observed revival of the two species. Except in unusual instances the counts were continued several days beyond the cessation of revival. The periods used are, then, believed to be appropriate for the insects used and the conditions obtaining in these experiments.

In view of these considerations the question naturally arises as to what may be considered a proper interval after fumigation to check results of the operation. In the first place, the interval apparently varies with the species of insect; certainly it is very different for Oryzaephilus adults and Plodia larvae. Even when viewing the record established through protracted examination for a given species in a single fumigation, the opposing and overlapping trends of revival and subsequent death make most difficult the selection of a particular interval which is manifestly a true indication of effectiveness. Furthermore, variation in different fumigations of one or more of the several pertinent conditions has the effect of advancing or retarding the revival period. Since, in commercial fumigation, these governing factors cannot accurately be gauged, it appears to the authors impracticable to establish any arbitrary interval which would constantly provide a correct expression of effectiveness. Rather, several examinations must be made. The final count does not provide a fair indication of the kill effected because it reflects the probable death, as above discussed, of some individuals due to the untoward conditions of confinement during the protracted examination. Therefore, in dealing with the data herein recorded, the maximum revival, or minimum kill, appears to be the most satisfactory index of effectiveness. However, in the light of the above discussion concerning the possible influence of methods upon recorded revival, this basis of gauging effectiveness may be held slightly to undervalue the benefits of the operation. Notwithstanding, it is regarded as the most accurate, uniform indication available.

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Scientific Notes

The Quantity of Fish Oil to Use as an Adhesive in Lead Arsenate Mixtures. In Bulletin No. 1439 of the United States Department of Agriculture, entitled "Fish Oil, an Efficient Adhesive in Arsenate of Lead Sprays," it was recommended that 4 quarts of fish oil be used to 400 gallons of spray mixture containing 25 pounds of powdered lead arsenate. Experiments conducted since this bulletin was submitted for publication have shown that the amount of fish oil should depend on the amount of lead arsenate that is used and that 3 quarts is sufficient for 25 pounds of powdered lead arsenate. If the amount of lead arsenate is reduced or increased, the fish oil should be reduced or increased proportionately. This should be the rule regardless of the amount of water used, but does not apply to mixtures containing Bordeaux.

For every pound of powdered lead arsenate contained in the spray mixture add 4 ounces by weight of fish oil.

CLIFFORD E. HOOD,
U. S. Bureau of Entomology, Melrose Highlands, Mass.

Can Baits be Used in Scouting for Injurious Insects? During the season of 1926, the writers conducted experiments with baits in apple and peach orchards in Maryland with the view of capturing the codling moth, *Carpocapsa pomonella* L., and the Oriental fruit moth, *Laspeyresia molesta* Busk. In an apple orchard baited for the codling moth, 13 moths of this species and 17 moths of the Oriental fruit moth were captured. In two peach orchards over 19,000 Oriental fruit moths were taken. The baits used in these tests included syrups diluted with water and evaporated fruits suspended in water.

The results of these investigations suggested to the writers that the practical application of facts derived from research in insect chemotropism might well be extended from the field of control, where its importance is now recognized, to that of scouting for injurious species in suspected areas not known to be infested.

Attractive baits for insects other than those mentioned above are already known,

and it therefore seems reasonable that such materials could be utilized to advantage to supplement ocular inspection in scouting for these pests. Further experience may show that the application of chemotropism in scouting for injurious insects may prove of equal if not of greater value than in insect control.

E. H. SIEGLER and LUTHER BROWN,
Deciduous Fruit insect Investigations, United States Department of Agriculture, Bureau of Entomology

The True Identity of the Citrus Mite. A good deal of confusion has existed among various authorities in recent years as to whether or not the citrus mite and the deciduous red mite are the same species. Certain entomologists have claimed that both of these red spiders are identical with the European red mite, *Paratetranychus pilosus* C. & F.

The present writers have always maintained that the citrus mite, *Paratetranychus citri* McG., is entirely distinct from the European red mite of deciduous trees. About two years ago the undersigned contributors undertook to settle the matter beyond argument, if possible. The problem was undertaken both through rearing tests and further anatomical studies. Citrus mites were sent from Southern California to Yakima, Wash., where Mr. Newcomer attempted crossing the male citrus and the female deciduous forms, and the male deciduous with the female citrus forms. Checks were conducted where citrus males and females were bred, and where deciduous males and females were reared. In addition, deciduous mites were sent from Yakima, Wash., to Lindsay, Calif., where an attempt was made by Mr. McGregor to rear them on citrus foliage.

A paper should appear before long in one of the leading scientific journals which will present in detail the results of these studies. We feel that it may not be amiss at this time to briefly announce the outcome of these studies, without supporting our findings by data of any sort.

It was found that the citrus mite would not breed with the deciduous mite, nor would the deciduous mite maintain itself successfully on citrus trees. Specimens of the European red mite, sent to us from Germany, proved to be entirely different in their anatomy from the citrus mite.

These facts have led us to reach the final conclusion that the citrus red spider of California and Florida is a distinct species, apart from that of the deciduous red mite. The proper technical name of the citrus mite is *Paratetranychus citri* McG., while the deciduous red mite will probably continue to be called *P. pilosus* C. & F.

E. A. MCGREGOR,
E. J. NEWCOMER.

Common Insect Pests Prefer Other Host Plants in Haiti. It comes as a considerable shock to an experienced Entomologist to find some common insect, with whose habits he considers himself reasonably familiar, under different circumstances or in another country occurring on quite a different host. "La Pulga Americana" (the American flea-beetle) of the Porto Rican tobacco growers, *Systena basalis* J. Duval, is by no means confined to tobacco or to Solanaceous plants even in Porto Rico, but one ordinarily finds it in greatest abundance on such hosts, and supposes its presence on other plants to be more or less accidental. How upsetting to all preconceived ideas, then, to find what appear to be considerable numbers of the same beetle in Haiti feeding on the leaves and calyces of cotton! There is no question

about the indentification, for Dr. Schwarz confirmed it; the cotton was not some special variety occurring only in Haiti, but Meade cotton; the beetles were feeding on the cotton because they liked it and not because of the absence of a more suitable host, for many acres of tobacco were near-by, yet on the tobacco no beetles could be found. There was no explanation; it was merely so. This observation was made at St. Michel, Haiti, in February, 1925.

The Pumpkin Bug, *Nezara viridula* Linn., is most often recorded from the Lesser Antilles on cotton, but one thinks of it in the Greater Antilles as a pest of garden vegetables, especially tomatoes and peppers. There is one Porto Rican record of its occurrence on tobacco at San Lorenzo in 1921 and causing considerable damage, but the first personal observation on this host was at Cap-Haitien, Haiti, in January, 1927. Blackened and withered central buds and tips of the larger leaves of the tobacco plants showed in a striking way the apparent injury caused by these big green bugs. The grower was surprisingly unconcerned, claiming that the withered plants would recover in a few days, especially if the abundant rains continued, but admitted that the effects might be really serious during dry weather. All stages of the insect were present in abundance in the tobacco field, and the evidences of the feeding of the adults and large nymphs were everywhere to be seen. Despite its absence in tobacco fields in other parts of Haiti, and its abundance on other hosts, *Nezara viridula* was far too common in the tobacco fields at Cap-Haitien for its presence and its choice of a host plant there to be considered an accident.

GEORGE N. WOLCOTT, *Port-au-Prince, Haiti.*

Increasing Nicotine Evolution from Tobacco Dust.[1] The use of tobacco dust for the control of different insects has not increased in proportion to its importance, mainly due to the slow volatilization of the nicotine. Under certain conditions tobacco dust might be preferable over nicotine dust mixtures if nicotine evolution can be increased.

A series of laboratory experiments were conducted during 1924 and 1925 with tobacco furnished by the Kentucky Tobacco & By Products Company. The tobacco was ground to pass a 200 mesh sieve, and had after grinding a nicotine content of 1.53%. The material was slightly alkaline.

The tobacco dust was mixed in different proportions with hydrated lime, dolomite and Miltown Ball Clay No. 9. After the nicotine evolution was compared from these mixtures the most promising received small quantities of sodium carbonate. Two grams of the mixtures were distributed with the aid of a pepperbox over cheesecloth clamped between the upper and lower parts of a Novy bacterial culture apparatus used in our studies on nicotine evolution (N. J. Agr. Exp. Sta. Bul. 400). Air conditioned to a relative humidity of 73.4% was drawn through the apparatus at a rate of 6 liters in 10 minutes for a period of 72 hours and at a temperature of 80°F. One sample was kept dry and another running parallel moistened at intervals to simulate dew. The latter samples were moistened with tap water blown from an atomizer (5 blows) after 7–8 hours run, this moistening was repeated after 28 hours. There the sample remained dry for the first 7–8 hours, was moistened and run for 24 additional hours, then moistened again and left for the rest of the 72 hours. The parallel sample was left dry during the whole period.

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[1]Paper No. 332 of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

The results for the mixtures running 72 hours in percentage nicotine evolved are given in Table 1. When the mixtures were kept dry tobacco dust alone evolved more nicotine than when mixed with any one activator tried. Tobacco dust moistened released less nicotine than dry, the same being the case with mixtures of tobacco dust and Miltown Ball Clay. Nicotine evolutions increased considerably from moistened tobacco dust mixed with lime and dolomite. Additions of small quantities of sodium carbonate to the mixtures practically doubled nicotine evolutions.

The nicotine in the dust is driven off by the alkali; when the mixture is moistened the alkali will penetrate better into the tobacco and consequently when such mixtures are placed in the soil near a plant to be treated or sprayed when dew has access to them nicotine will be released more rapidly. Miltown Ball Clay is acid in character and does not have this effect but in contrary holds possibly part of the nicotine evolving from the tobacco.

TABLE 1. PER CENT OF NICOTINE EVOLUTION FROM MIXTURES KEPT DRY AND MOISTENED AT INTERVALS

No.	Mixture (by weight)	Nicotine evolved	
		dry	moistened
3	Tobacco dust alone	3.83	3.16
5	Tobacco 50, $Ca(OH)_2$ 50	1.42	8.17
6	Tobacco 50, Dolomite 50	1.34	8.79
7	Tobacco 50, Miltown Ball Clay No. 9 50	1.42	1.34
8	Tobacco 50, Dolomite 45, Na_2CO_3 5	1.57	16.91
9	Tobacco 50, Dolomite 47, " 3		14.90
10	Tobacco 50, Dolomite 49 " 1		16.02
12	Tobacco 50, $Ca(OH)_2$ 49 " 1		20.56

WILLEM RUDOLFS

The Tulip or Iris Aphid in Santa Cruz County, California. *Anuraphis tulipae* Boyer de Fonscolombe has been for several years a pest of more or less serious nature to bulbs around Santa Cruz, Calif. While no protracted studies of this insect have been attempted by the writer, some observations of interest are herewith reported. In this district the bulbous iris appears to be the favored host and the infestation is most serious during the summer months while the bulbs are in the storage shed. Accordingly the insect is termed the "storage aphid" by many of the growers. As the American Association of Economic Entomologists has recommended the common name "tulip or iris aphid," the term "storage aphid" should be discouraged. The commercial growers of Santa Cruz County have trouble with this aphid on only one other group of plants, viz., the Mourning Iris, *Iris susiana*, one of the rhizome types. Tulips are not grown commercially in this section.

From the reports of the horticultural commissioner's office of Santa Cruz County and of the growers it is evident that the infestation was quite heavy in the summer of 1924. However, in 1925, no infestation of even the slightest degree was noted by any of the iris producers, and several searches by the writer failed to locate any specimens whatever. During the past summer (1926) all growers had trouble with this aphid, and the writer had no difficulty in locating infested iris bulbs in any of the warehouses. One contributing cause of the non-appearance of the aphids in 1925 is the fact that practically all iris bulbs were fumigated during the infestation of 1924.

During the summer and autumn of 1926 the writer kept about 500 infested iris bulbs in the laboratory. Commencing about September 10th and continuing to approximately October 15th there was a marked production of winged forms which congregated in considerable numbers on the laboratory windows. Examination of some of the bulbs during this period showed that these winged forms were coming from both plump and shrivelled bulbs, indicating that conditions outside of the bulbs rather than the drying of them were causing this phenomenon. Winged and wingless specimens collected at this time were identified by Dr. P. W. Mason of the Bureau of Entomology as *Anuraphis tulipae* Boyer. (Authorship of this species is sometimes indicated "Fonsc.;" the full name of the author is Boyer de Fonscolombe.)

Box fumigation with calcium cyanide has been considered by the various growers as very satisfactory in controlling attacks of this aphid. During the 1924 season they used dosages of from eight to sixteen ounces of calcium cyanide per 100 cubic feet with exposures of two hours duration. This was spread directly on burlap sacks soaked in water, so that full evolution of the hydrocyanic acid gas was not obtained, but there is little doubt that the resulting concentration was sufficiently high to kill all aphids, and none of the growers reported injury to their bulbs. The writer made three tests with granular calcium cyanide in August 1926, with the following results:

Rate		Number of aphids dead	Number alive	Mortality %
A.	1.76 oz. per 100 cu. ft.	522	1	99.8
B.	2.35 oz. per 100 cu. ft.	1204	0	100.
C.	2.35 oz. per 100 cu. ft.	664	0	100.

In these tests the exposure lasted two hours.

The writer's method of application was to place a damp (*not* soaking wet) sack on the floor of the fumigation box, over which three or four thicknesses of dry newspaper were laid, and to spread the material thinly over the paper.

Fumigated iris bulbs from these tests and from several fumigations by various growers were watched closely for evidence of injury, but nothing was observed to indicate any harmful effects.

It is probable that the amount of calcium cyanide could be reduced considerably if the period of exposure was prolonged, but in view of the fact that there is no injury at an approximate rate of two ounces per 100 cubic feet, the two hour exposure is deemed more desirable as the additional labor cost with longer exposures would be much greater than the saving in cost of material.

CHARLES F. DOUCETTE, *U. S. Bureau of Entomology,*
Bulb Insects Field Station, Santa Cruz, California

Note on the Continuous Breeding of *Musca domestica*. The difficulty of rearing house flies during the winter months, and the importance of maintaining a continuous supply during the entire year for experimental uses and insecticide tests, induces the writer to publish the following note on a successful method for meeting the seasonal difficulties in this field.

In earlier publications,[1] it was stated that, "Two species of flies, namely, *Musca domestica* and *Stomoxys calcitrans* have been reared from approximately the middle

[1]The effect of food on longevity and reproduction in flies. *J. Exp. Zool.*, 1923, xxxviii, 383–412. Rearing flies for experimental purposes, with biological notes. *J. Econ. Ent.*, 1924, xvii, 486–496.

of April until the middle of December. The artificial conditions (artificial heat, food, etc.) seem to manifest their influence at this time, however, for it has so far been impossible to rear these flies during the remaining four months of the year." Since the summer of 1924, up to March, 1927, house flies have been continuously bred. No further attempts at breeding *Stomoxys* throughout the winter were made, but doubtless can now also be accomplished if the further directions, outlined below, for *Musca domestica* are followed.

It often occurs that when all of the conditions, enumerated in the articles referred to, are fulfilled with respect to adult and larval food, to moisture of the larval medium, to temperature and atmospheric humidity, cultures cannot be maintained. Sometime during December or January fertile female house flies will oviposit; the progeny grow to about half their normal size and then die. Experience has demonstrated that the medium (horse manure in this case) is more deficient in food value for fly larvae in winter than during the warmer months. Whether this is due to a change in the bacterial flora on which maggots reared on certain foods primarily feed; whether it is due to a reduction in the number of bacteria for some reason, or due to some other factor, correlated with the horse's winter diet, is unknown. Neverthless, it has been found that when fly larvae in winter cease to grow the addition to the manure every few days of a few cubic centimeters of a heavy suspension of yeast cells in water will correct matters and will enable the larvae to grow and mature. This procedure has also proven valuable in cases of overcrowding where too many eggs are laid and consequently more maggots emerge than the food value of the medium can support. In practice we dissolve a one pound bakery cake of commercial yeast in two liters of water. The suspension of yeast cells is then distributed in pint milk bottles and autoclaved, to kill fungi which often cause trouble, and stored on ice. When addition of yeast to the larval diet is indicated the suspension, which rapidly settles, is shaken vigorously and added every two or three days in amounts dependent upon the number of maggots present in a breeding jar.

Lastly, fresh horse manure should always be used for each new generation of flies. I have found that some investigators, at times, attempt to use the same manure for two or more generations and complain at the total loss of their flies. It should also be emphasized again that the manure must be maintained in a moist condition. For the proper feeding of the newly emerged adults and for other details the reader is referred to the articles mentioned.

R. W. GLASER, *Department of Animal Pathology of the Rockefeller Institute for Medical Research, Princeton, N. J.*

REPORT OF CONFERENCE OF ENTOMOLOGISTS AND PLANT PATHOLOGISTS AT LOGAN, UTAH, FEB. 9 AND 10, 1927

A conference of the Entomologists and Plant Pathologists of the Rocky Mountain region was held at the Utah Agricultural College in Logan on February 9 and 10, 1927. The conference was called by Director William Peterson of the Utah Agricultural Experiment Station to consider some of the insect and disease problems common to Utah and the surrounding states. The following program was carried out:

Introductory remarks—Director William Peterson.

Wireworms and their control—M. C. Lane.

The chalcis fly in alfalfa seed—C. J. Sorenson.

A statement of the beet leafhopper problem—I. M. Hawley.
Economic aspect of the beet leafhopper problem—R. H. Cottrell.
Present status of the investigation of the sugar-beet leafhopper—Walter Carter.
The curly leaf disease—Eubanks Carsner.
Storage rots of sugar-beets—C. M. Tompkins.
Minor diseases of sugar-beets—B. L. Richards.
Agronomic control—George Stewart.
Beet breeding—E. G. Titus.
Sugar-beet root-maggot—I. M. Hawley.
Alfalfa diseases—B. L. Richards.
Status of alfalfa weevil investigation—Geo. I. Reeves.
Showing of the alfalfa weevil film—property of the U. S. D. A.
Difficulties in control of alfalfa weevil—Claude Wakeland.
Prevention of spread of the alfalfa weevil—G. G. Schweis.
Current problems connected with the alfalfa weevil—Geo. I. Reeves.
The alfalfa weevil in the Mississippi Basin—C. L. Corkins.
Introduction of alfalfa weevil parasites—I. M. Hawley.
Some of the more important insect problems in the United States—J. E. Graf.
Summary of the work of the conference—Director William Peterson.

At the conclusion of each paper time was allowed for a general discussion. These discussions were a great aid to a better understanding of the various problems.

On Wednesday evening following the first day's conference, the staff of the Utah Experiment Station entertained the visitors at a banquet. Geo. I. Reeves acted as toast master.

A resolution committee consisting of I. M. Hawley, C. W. Hungerford, E. G. Titus, R. H. Cottrell and H. J. Pack was appointed by Director Peterson. Acting on the suggestion of this committee it was decided to hold a conference during February, 1928, in Salt Lake City. Director Peterson was asked to act as chairman of the meeting next year.

The following representatives of the U. S. Department of Agriculture were in attendance:

Bureau of Entomology:

J. E. Graf, Washington, D. C.; Geo. I. Reeves, I. M. Hawley, S. J. Snow, Salt Lake City, Utah; Walter Carter, Twin Falls, Idaho; E. W. Davis, Richfield, Utah; M. C. Lane, Toppenish, Washington.

Bureau of Plant Industry:

Eubanks Carsner, Riverside, California; Dean Pack, S. B. Nuckols, Gerald Thorne, Salt Lake City, Utah; C. M. Tompkins, Logan, Utah.

The following state experiment station workers were in attendance:

Wyoming: C. L. Corkins.

Idaho: Claude Wakeland, C. W. Hungerford, R. W. Haegele.

Nevada: G. G. Schweis.

Colorado: J. H. Newton.

Utah: Director William Peterson, P. V. Cardon, W. W. Owens, W. W. Henderson, H. J. Pack, C. J. Sorenson, G. F. Knowlton, B. L. Richards, F. B. Wann, H. L. Blood, Geo. Stewart, D. W. Pitman, D. C. Tingey, J. W. Carlson, G. Q. Bateman.

In addition, the Utah State Department of Agriculture was represented by F. E. Stevens, E. L. Barrett and W. W. Knudson; the American Smelting and Refining Company by A. F. Barney; the Utah-Idaho Sugar Company by E. G. Titus, and the Amalgamated Sugar Company by R. H. Cottrell, S. Christensen and eight field men.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1927

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $2.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A ten million dollar European corn borer campaign sets a new record in control work and is really a test in possibilities of organization and cooperation, since it is proposed to depend largely upon individual farmers to clean-up their own cornfields and corn waste, the government and state officials providing directions, supervision and later cleaning up areas not properly cared for, either through neglect or for some other cause. The clean-up is to be completed by May 1, easily possible with an early spring and favorable conditions. The corn belt is rightly exercised over the advance westward of the European corn borer and as a consequence general cooperation can be more easily obtained than were conditions different. There may be some difficulty in impressing upon thousands of individuals the need of close attention to details and it may prove something of a problem to do within the time limits the supplementary work made necessary for one reason or another. The plan is sound in emphasizing possibilities of control through modifications in agricultural practice and if this can be thoroughly demonstrated, this feature alone may justify the expenditure. This undertaking must result in a considerable decrease in the infestation in the more badly infested areas and thus lessen materially the probability of rapid spread. The execution of the project will be watched with the greatest interest. It is something new for America, intriguing in its scope, and demanding the support of all those in position to render material aid. There must be no sparing of effort to demonstrate possibilities in this gigantic undertaking.

Current Notes

Mr. E. Hobbs, Entomologist at Substation No. 15 of the Lower Rio Grande Valley, Texas, has resigned.

Mr. H. L. Fackler has recently been appointed assistant entomologist of the Tennessee Station, Knoxville, Tenn.

Mr. H. L. Seamans of the Lethbridge, Alta, Laboratory, addressed students of the Raymond Agricultural School on "Insects and Their Control," on January 21.

Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology, spoke at Cornell University on January 27, on "Fifty Years of Economic Entomology."

The Department of Entomology of the Arkansas University and Station, will be housed in a new agricultural building now being erected at a cost of $250,000.

Messrs. B. R. Coad and Elmer Johnson left Tallulah, La., on December 30, for an extended trip to Arizona, where they will study the Thurberia weevil situation.

Mr. J. N. Tenhet of the Bureau of Entomology, returned December 31, to Clarksville, Tenn., from his temporary assignment with the Federal Horticultural Board at Houston, Texas.

Mr. Henry H. Richardson, a graduate of the Massachusetts Agricultural College, has recently been appointed Junior Entomologist, to fill a vacancy at the Gipsy Moth Laboratory, Melrose Highlands, Mass.

Mr. H. G. Crawford, Entomological Branch, Ottawa, Canada, gave a lecture on "The Control of Insects Affecting Farm Crops," at an Agricultural Short Course at Russell, Ontario, on February 4.

Mr. H. F. Barnes, who has a traveling fellowship from the Southeast Agricultural College, Wye, England, is spending the winter studying gall midges with Dr. E. P. Felt, at Albany, N. Y.

According to *Science*, the extensive collection of Coleoptera accumulated by the late Mr. Fred C. Bowditch of Brookline, Mass., has been presented by his family to the Museum of Comparative Zoology, Cambridge, Mass.

Dr. M. Kamal has recently completed his studies in the United States and is returning to Cairo, Egypt, where he will be employed in entomological work by the Ministry of Agriculture.

Messrs. L. L. Huber and R. M. Salter presented a paper on "Corn Borer Research in Ohio," at the 19th annual meeting of the American Society of Agronomy held at Washington, D. C., November 18–19, 1926.

Messrs. Blanchard and Luginbill of the United States Federal Laboratory at Monroe, Mich., visited the Chatham, Ontario, laboratory on January 22, to secure host material for rearing *Exoristes* and *Habrobracon* parasites.

Mr. K. M. King of the Saskatoon, Sask. Laboratory, visited Regina, Sask., January 25–26, and conferred with certain provincial officials in connection with the continuation of the excellent cooperation enjoyed during 1926.

Dr. Charles H. O'Donoghue, Professor of Zoology, University of Manitoba, Winnipeg, visited Ottawa on January 5, and spent some time with the Dominion Entomologist and other Branch officers, discussing various matters of entomological interest.

Dr. J. M. Swaine, Associate Dominion Entomologist, and Ralph Hopping, Specialist on Forest Insects for the Canadian Government, were in Washington recently studying insect collections and conferring with specialists on forest insects of the department.

Mr. G. M. Stirrett, of the Chatham, Ontario Laboratory, attended a European corn borer conference held at London, Ontario, on January 27. The conference brought together those in charge of the enforcement of the provincial European corn borer control legislation.

Professor William E. Hoffmann, head of the Biology Department of Lingnan University, Canton, China, represented the University and South China at the Third Pan-Pacific Science Congress recently held in Tokyo, where he gave papers on entomology and parasitology.

According to *Experiment Station Record*, Dr. C. H. T. Townsend has been placed in charge of the Peruvian Agricultural Institute of Parasitology, which has recently been organized to study the insect pests and plant diseases of the coastal region of Peru.

Dr. B. A. Porter, in charge of the laboratory of the Bureau of Entomology, at Vincennes, Ind., spent the latter part of December and a part of January in Washington, conferring with Bureau officials regarding plans for the coming season's work.

A corn borer exhibit was displayed at the Peninsular Winter Fair held at Chatham, Ontario, in the early part of December. Messrs. A. B. Baird, G. M. Stirrett, and H. F. Hudson assisted in giving information to the public on insect control.

Dr. A. A. Granovsky, of the University of Wisconsin, spent several days in January at the Bureau of Entomology, studying aphids with Dr. Mason. Dr. Granovsky is especially interested in the Callipterini and is working on a monograph of this group.

Mr. G. G. Ainslie, formerly in charge of the Knoxville, Tenn., laboratory of the Bureau of Entomology, resigned from the Bureau service, effective January 31, 1927, for the purpose of entering commercial work. His address, as formerly, will be Knoxville, Tenn.

Mr. G. A. Ficht, now of the Department of Entomology, Iowa State College, Ames, was a visitor at the Chatham, Ontario, laboratory at the end of December in connection with the securing of corn borer material for exhibition work in Iowa.

Dr. Philip Luginbill, of the Monroe, Mich., corn borer laboratory, and D. S. Lacroix, of the Sandusky, Ohio, corn borer laboratory, were at Toledo, Ohio, on January 24, for consultation with D. J. Caffrey relative to winter phases of the investigational work.

Mr. L. S. McLaine gave an address entitled, "Some Problems of the Entomologist," before the Lion's Club of Ottawa, on January 11, and one on "Small Friends and Foes," illustrated by motion pictures, before school children, at the Victoria Memorial Museum, Ottawa, on February 12.

According to *Science*, Professor Mario Bezzi, the well-known authority on the Diptera of the world, has been appointed professor of zoology and director of the zoological museum in the Royal University of Turin, Italy, as a successor to the late Professor E. Giglio-Tos.

Mr. R. P. Gorham of the Fredericton, N. B. Laboratory, visited St. John, N. B., January 13–14, where he conferred with Dr. William McIntosh of the Natural History Museum, concerning the history and location of recent armyworm outbreaks in the province, and their possible recurrence in 1927.

Mr. Perez Simmons of the Bureau of Entomology reports that recently he and G. W. Ellington discovered that the Angoumois grain-moth larvae sometimes leave the grain and spin cocoons in the ground. This is a new fact that appears never before to have been recorded.

Mr. C. H. Gable, formerly in charge of the San Antonio, Texas, laboratory of the Bureau of Entomology, resigned from the Bureau, effective December 31, 1926, to enter commercial work. Mr. E. V. Walter, of the Tempe, Arizona, laboratory, has been placed in charge of the laboratory at San Antonio.

According to *Science*, Professor C. T. Brues, of Bussey Institution, Harvard University, spent the early part of the winter at the Harvard Tropical Laboratory at Soledad, Cuba, investigating the insect fauna of the region. He was accompanied by Mrs. Brues, who made studies of the local grass flora.

According to *Science*, during February, Professor Wesley R. Coe of the department of zoology at Yale University, who is absent on sabbatical leave for the college year, was engaged in investigations of the invertebrate fauna of the Pacific Coast, with headquarters at the Scripps Institution of Oceanography in California.

Dr. George H. F. Nuttall, Quick Professor of Biology, and Director of the Molteno Institute for Parasitology at Cambridge, England, gave the Gehrman lecture at the University of Chicago, January 11, on "Insects and Disease." He lectured on the three following days at the University of Illinois, giving one lecture on "Ticks."

Professor A. W. Baker and Mr. R. Ozburn, of the Entomological Department, Ontario Agricultural College, Guelph, visited the Entomological Branch at Ottawa, December 28 to January 4, and with the assistance of officers of the Division, made a selection of duplicate insect specimens from the National Collection, for incorporation in the College collection at Guelph.

On November 26 and 27, the State Plant Board of Mississippi, together with entomological workers of that State, held a meeting at A. & M. College, Miss., at which Mr. Oliver I. Snapp of the Bureau of Entomology, gave an address on the results of recent experiments on the control of peach insects in the South.

Mr. E. R. Buckell, Vernon, B. C. Laboratory, attended the meetings of the British Columbia Stockbreeders' and Fruit Growers' Associations held at Vancouver in the early part of December. While in Vancouver, Mr. Buckell held consultations with several officials and made arrangements for provincial cooperation in grasshopper and Colorado potato beetle control work during 1927.

Mr. W. J. Brown, M.Sc., has been appointed to the position of Assistant Entomologist, Entomological Branch, Ottawa, dating from January 31. This position became vacant on the resignation of Mr. H. L. Viereck in April, 1926. Mr. Brown, who has specialized in coleoptera, was formerly a lecturer in entomology at the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

At a meeting of the Entomologists Group of the Professional Institute of the Civil Service of Canada, held at Ottawa on December 17, Dr. W. H. Brittain, Professor of

Entomology at Macdonald College, Quebec, gave an interesting, amusing and informative address on certain aspects of his recent trip around the world undertaken in the interests of the American Cyanamid Company.

At the annual meeting of Massachusetts gipsy moth superintendents, Boston, January 18, brief addresses were made by Dr. W. A. L. Bazeley, A. F. Burgess, George A. Smith, H. L. McIntyre, Dr. T. J. Headlee, W. C. O'Kane, H. L. Bailey, and Dr. W. E. Britton. Most of these men took part in a conference the preceding afternoon on methods to be followed in gipsy moth work.

A description of the "Modified Electro-Gutzeit Apparatus for the Detection and Estimation of Minute Amounts of Arsenic in Insect Tissue and in Arsenical Residues" will appear in the Journal of Biological Chemistry. Those desiring a reprint of the article should communicate with Dr. D. E. Fink, Dept. Zoology, University of Pennsylvania.

According to *Science*, Dr. William Schaus, Honorary Assistant Curator of Insects, U. S. National Museum, has recently purchased and donated to the Museum a collection of moths from Bolivia containing about ten thousand specimens. This is a large and important addition to the Museum's collection of South American moths, which is believed to be the largest in the world.

Mr. S. E. McClendon, Bureau of Entomology, Thomasville, Ga., reports that the fall examinations of corn grown and housed on St. Simons Island, Ga., showed that no rice weevils were present. This fact is of interest because, when the control experiments were started on this island about four years ago, the rice weevil was a very serious and widespread pest.

Mr. George I. Reeves, in charge of the Salt Lake City Laboratory of the Bureau of Entomology, spent December 13 and 14 at Ames, Iowa, in consultation with Professor Carl J. Drake, of the Iowa State College of Agriculture, regarding the spread of the alfalfa weevil, and addressed the faculty and advanced students of the Department of Zoology at that college.

Mr. C. E. Petch, of the Hemmingford, Quebec, Laboratory, delivered several addresses on various phases of entomology before the Men's Club and the Boys' Club of the Y. M. C. A., at Sherbrooke, and the Men's Industrial Classes at Sherbrooke High School, early in January. He also gave a lecture on "Insects of the Flower Garden," before the Women's Institute, Hemmingford, on January 7.

According to *Science*, Dr. T. D. A. Cockerell, Professor of Zoology at the University of Colorado, expects to sail for England next June, and thence go to Russia and Siberia, later back to Russia; in October to England, and about November 1 to India; about February 1, to Australia and New Zealand by way of the South Sea Islands, returning to Boulder, Colo., about September 1, 1928.

Professor W. C. O'Kane has recently been elected a member of the Authors' Club of London, England, and last summer was elected to membership in the Authors' Club of New York. The committees responsible for the selection of new members in both clubs indicated that the recent books on the White Mountains and the Green Mountains are the literary works that have brought this honor to Professor O'Kane.

Dr. Edith M. Patch, Entomologist of the Maine Station, will spend several months in England the coming summer, where she will continue her investigations

of economic species of aphids. Her plans include sailing from St. John, N. B., on April 8, on the Montcalm, and her laboratory headquarters will be at the Rothamsted Experimental Station, Harpenden, Hertsford, England. Dr. Patch will be accompanied on the trip by her sister, Miss Alice S. Patch.

Mr. R. B. Falkenstein, Instructor in Biology at Lingnan University, Canton, China, has returned to America on furlough, returning via Siberia and Europe. His place is being filled by Mr. R. E. Wall. Both Mr. Falkenstein and Mr. Wall were formerly of the staff of the University of Minnesota. The head of the Biology Department at Lingnan University, Professor William E. Hoffman, is also a former member of the staff of the University of Minnesota.

Mr. Arthur Gibson, accompanied by Mr. L. S. McLaine, attended the 21st annual convention of the Ontario Horticultural Association held at Toronto, Ontario, on February 10 and 11, and spoke on the subject, "Inspection of Nursery Stock." Delegates were in attendance from the various horticultural societies throughout Ontario. The organization, comprising as it does all the local societies, has a membership of 70,000. About 500 delegates were in attendance at the Toronto meeting.

For the period ending January 21, 1927, the shipments of corn borer parasite material from Europe included a total of 84,000 cocoons of *Microgaster tibialis* Nees, 12,500 cocoons of *Eulimneria crassifemur* Thom., and 645,000 host larvae, from which five additional species will be reared. These shipments will be continued and supplemented by laboratory rearings. Preliminary shipments of parasite material from India and from Japan have also been received through the cooperation of the Japanese beetle investigators.

In 1926, the Dominion Entomologist of Canada arranged for the sending to New Zealand of living Chrysopids collected in British Columbia, in the hope that they would assist in checking the ravages of certain destructive aphids. Owing to the success attending this shipment, further arrangements were made to send a second shipment, and this, consisting of over 5,000 living individuals, was dispatched to New Zealand in December. Messrs. E. R. Buckell, A. A. Dennys, and W. Downes assisted in the collecting and dispatching of this material.

Acting on instructions from the Dominion Entomologist, the officers of the Hemmingford laboratory, Messrs. C. E. Petch and G. H. Hammond, made collections of parasitized white grubs, consisting of over 1500 specimens, for shipment to Dr. David Miller, Government Entomologist at Wellington, New Zealand. It is hoped that the parasites, which belong to the species *Microphthalma michiganensis*, will establish themselves in New Zealand and assist in the control of chafers of the genus *Odontria*. Dr. Miller has announced the safe arrival of the parasitized material.

On January 19, about 1500 persons attended the special session on the European corn borer, held in connection with Farmers' Week, at the Auditorium of the College of Agriculture, University of Illinois, at Urbana. Addresses on the corn borer were given by D. J. Caffrey of the Bureau, R. M. Salter of the Ohio Agricultural Experiment Station, R. I. Shawl of the University, and Theo. Brown. The new moving picture films of the corn borer were shown, and a special corn borer exhibit was also displayed. Dr. S. A. Forbes presided at the session.

Observations in the past few months have shown a very heavy mortality of the San José scale in the Georgia peach belt; heavier than at any other time in the last

five years. It is believed to be due to twice-stabbed ladybird beetles. In many cases the scale coverings, with no bodies under them, were found clinging to the trees. The question has arisen whether the unusual abundance of ladybird beetles in 1926 is in any way correlated with the general use of lubricating-oil emulsion for the last several years.

A conference of entomologists and commissioners of agriculture was held at the Japanese Beetle Laboratory, Riverton, N. J., February 10. Among those present were Dr. A. L. Quaintance, Associate Chief, Bureau of Entomology, Washington, D. C.; C. H. Hadley, Director Bureau of Plant Industry, Harrisburg, Pa.: Dr. T. J. Headlee, State Entomologist, New Brunswick, N. J.; Dr. W. E. Britton, State Entomologist, New Haven, Conn.; Loren B. Smith and C. W. Stockwell, Japanese Beetle Laboratory, Riverton, N. J.; W. C. Duryea, Commissioner of Agriculture, Trenton, N. J.; R. B. Willson, Commissioner of Agriculture, Dover, Del.; and B. D. Van Buren, Assistant Director Bureau of Plant Industry, Albany, N. Y.

Mr. D. M. Rogers, Assistant in charge of the gipsy-moth quarantine and inspection work of the Bureau of Entomology, has resigned from the service. He had been associated with the gipsy-moth work for many years. He was the first man employed by the Bureau when the gipsy-moth work was begun in 1906, and had been in charge of quarantine and inspection since 1913. He and Mrs. Rogers have gone to California, where he plans to carry out experiments in plant breeding. Dr. J. N. Summers, associate entomologist in the Bureau, connected with the gipsy-moth investigations since June, 1911, has been appointed to the position left vacant by the resignation of Mr. Rogers.

According to the *Official Record*, Mrs. C. V. Riley, widow of Doctor Riley, predecessor of Dr. L. O. Howard as chief entomologist of the Department, has donated to the library of the National Museum the scrapbooks of economic entomology which were kept by her husband in the period of his activity from 1865 to 1894. These volumes, about 100 in number, contain many articles of great historical interest. In giving these scrapbooks to the Museum, Mrs. Riley wished to have them housed in the same place as the Riley collection of insects. The donation is of great importance to entomologists, as it makes available much information otherwise very difficult to obtain.

A corn borer conference was held at Chicago on January 21 and 22, to standardize recommendations for the proper use of existing plow equipment and accessories thereof, to meet the requirements of the corn borer clean-up campaign this spring. The conference was attended by experts of the large manufacturers of farm machinery. Representatives were also present from the Agricultural Engineering Departments of Michigan, Indiana, Ohio, and Pennsylvania. Prof. A. L. Wiancko, of the Agronomy Department of Purdue University, and Mr. Smith, President of the County Agents' Association, attended. The Bureau was represented by L. H. Worthley and D. J. Caffrey. Professor C. O. Reed, of the Agricultural Engineering Department of Ohio State University, presided.

Recent visits to the Division of Insects, U. S. National Museum, have been made by the following entomologists: Dr. H. W. Allen, Riverton, N. J., December 2 and 3; Dr. C. J. Drake, Ames, Iowa, December 24–26; Drs. H. B. Hungerford, Lawrence, Kansas, and D. M. DeLong, Columbus, Ohio, December 27; Dr. M. Kamal, Cairo,

Egypt, December 24; Dr. W.A. Riley, St. Paul, Minn., December 14 and 15; G.M. Greene, Harrisburg, Pa., December 31; G. B. Merrill, Gainesville, Fla., December 24 and January 3–5; Dr. H. Prell Tharandt, Saxony, Germany, December 13–23; H. F. Barnes, Wye, England, Christmas week; Graham Fairchild, Harvard University, Christmas week; Dr. J. M. Swaine, Ralph Hopping, Ottawa, Canada, January 3; Dr. E. D. Ball, Sanford, Fla., January; Dr. S. B. Fracker, Madison, Wis., January 1; Dr. T. H. Frison, Urbana, Ill., January 3–5; Dr. W. J. Holland, Pittsburgh, Pa.

A hearing was held in Washington, D. C., February 8, by the Federal Horticultural Board regarding the proposed extension of the European corn borer quarantine. The quarantine has been extended (effective March 1) to include Bayonne and Jersey City, New Jersey; much extra territory in Pennsylvania; Staten Island, Kings, Queens, and Nassau Counties, Long Island, New York; Charlestown, Narragensett, North Kingston, South Kingston and Westerly in Rhode Island; and the towns of East Lyme, Groton, New London, Stonington and Waterford in Connecticut. Among the entomologists present were noted: Frank N. Wallace, State Entomologist, Indianapolis, Ind.; C. H. Hadley, Director, Bureau of Plant Industry, Harrisburg, Pa.; E. N. Cory, State Entomologist, College Park, Md.; W. E. Britton, State Entomologist, New Haven, Conn.; P. A. Glenn, Chief Nursery Inspector, Urbana, Ill.; C. L. Marlatt, E. R. Sasscer, W. H. Larrimer and L. H. Worthley of the Bureau of Entomology.

At a conference of representatives of the Committee of the international European corn borer organization and representatives of the Department of Agriculture, held in Washington early in January, the need for a careful administrative consideration of the research program in reference to the control of the European corn borer was made plain. In view of the emergent character of the situation, it seemed important that there be called a similar conference of the station directors in the states concerned, to consider the research now in progress bearing on the problem and to map out a research program for the coming season, in which the various states join with the Department. Such a conference was called by Dr. A. F. Woods, Director of Scientific work, to meet in Washington, January 6 and 7. The conference was attended by station directors, entomologists, agronomists, farm machinery engineers, and other representative officials of the Corn Belt and of states not immediately in that area. The research program of the Department was outlined in detail, and the many investigational phases bearing either directly or indirectly on the problem of control were freely discussed. The research programs of the various states concerned were presented and likewise discussed. It was the general opinion of those in attendance that practically nothing had been omitted from the combined program of the Department and the states, and while the enlargement of some of the projects was arranged for, no new lines of work were suggested.

Horticultural Inspection Notes

Four winter nests of the brown-tail moth have recently been found at Wolfville, N. S.

Mr. W. N. Keenan gave an address on "The Work of the Division of Foreign Pests Suppression," before the Gyro Club of Fredericton, N. B., on January 11.

The Central States Plant Board held its annual meeting at Madison, Wis., on March 4 and 5 in connection with the meeting of the North Central States Entomologists.

Mr. L. M. Scott of the Federal Horticultural Board recently made a trip to Philadelphia, New York and Boston to confer with the men in charge of these ports.

Mr. R. W. Woodbury, who has been employed as a Plant Quarantine Inspector in Washington for about two years, was recently transferred to Boston to assist in carrying on the work at that port.

Detroit, Mich., has been designated as a port of entry for plant material, and an Inspector will shortly be appointed to look after the interests of the Federal Horticultural Board at that place and at Port Huron.

Mr. Spessard, Plant Quarantine Inspector of the Federal Horticultural Board, stationed at Washington, D. C., has been detailed temporarily to look after the Board's work in Baltimore in the absence of Mr. Prince, who is away because of illness.

As these notes are being prepared we have just been informed of the death of Mr. Nile M. Border. Mr. Border has been associated with the Federal Horticultural Board as an inspector stationed at New York and Philadelphia since September 5, 1925.

Mr. E. R. Sasscer of the Federal Horticultural Board is visiting the Mexican border ports to investigate some of the problems which have arisen, and to confer with the Inspectors in charge of the work. He expects to touch at all of the points on the border where Inspectors are stationed before returning.

Mr. Max Kisliuk, who has charge of the work of the Federal Horticultural Board at Philadelphia, has been detailed to make an investigation of the fruit fly situation in the Argentine Republic. Mr. William W. Chapman was placed in charge during Mr. Kisliuk's absence which will probably extend for a period of three or four months.

A ship from Argentina, which docked at Portland recently to discharge a part of its cargo of 14,000 bags of linseed, was found to have one of its holds badly infested with European earwig. The linseed was immediately loaded in freight cars, where it was given a heavy fumigation, and the boat allowed to proceed to Seattle where the vessel was fumigated to kill the insects.

The European Corn-borer Quarantine No. 43 has been extended following the public hearing at the Department of Agriculture held February 8, 1927. The extension involves the inclusion in the infested area of portions of two new states—Connecticut and New Jersey—and minor additions in Rhode Island and New York. A revision of the regulations under the Corn-borer quarantine, indicating these extensions, to be effective March 1, has just been issued.

Mr. E. M. Ehrhorn recently resigned his position as chief of the Plant Inspection Service for the Board of Agriculture and Forestry in the Hawaiian Islands. He has been succeeded by Mr. D. T. Fullaway, who was formerly engaged in collecting and rearing parasites of the more important insect pests of the Hawaiian Islands. Mr. L. A. Whitney remains as Associate Plant Inspector. Mr. Fullaway and Mr. Whitney are both collaborators of the Federal Horticultural Board.

It is with sorrow that we have to report the recent death of Mr. R. I. Smith, who for many years has been prominent in Entomological work. He has been associated since August, 1915 with the Federal Horticultural Board, and has had charge of its inspection work at Boston. Through Mr. Smith's untimely death the Board has lost a faithful worker, one whose place it will be difficult to fill, and those who were closely associated with him, a true friend.

The rules and regulations under the Foreign Corn-borer Quarantine (No. 41) have been revised effective January 1, 1927. The quarantine itself is unchanged. Under the revised regulations the entry of products covered by the quarantine is limited to clean shelled corn, clean seed of broom corn and broom corn for manufacture. Corn and seed of broom corn may be imported only under permit, and under requirements of inspection and certification from the country of origin. Reinspection of these articles will also be made at port of entry. Other restrictions on the entry of broom corn for manufacture remain unchanged. This quarantine now replaces and supersedes Quarantine No. 42 against Indian corn or maize from Mexico.

Apicultural Notes

The annual winter meeting of the North Carolina State Beekeepers' Association was held during the latter part of January at Raleigh, N. C.

A commercial organization of intermountain beekeepers to be known as "Mountain States Honey Producers Association," was formed at Laramie, Wyoming, during a meeting held there from February 21–24.

Recent visitors at the Bee Culture Laboratory of the Bureau of Entomology included Professor Francis Jager, of the University of Minnesota, and Mr. C. L. Sams, Specialist in Beekeeping, of the North Carolina State College of Agriculture and Engineering.

At the January meeting of the Arkansas Beekeepers' Association at Little Rock, a bee disease bill was recommended which provides for a full-time state bee-disease inspector, registration of all bees in the State, and a tax of ten cents per colony. The passage of the bill seems assured.

A radio program on bees and honey by the American Honey Producers' League, in cooperation with the Extension Service of the University of Wyoming, was scheduled for March 22 from the Laramie broadcasting station. Dr. A. P. Sturtevant, in charge of the Intermountain Bee Culture Field Station, and Professor C. L. Corkins, State Entomologist, were on the program.

Pacific Slope Notes

During the latter part of February, Mr. J. E. Graf visited the western stations of the Division of Truck Crop Insects in Idaho, California and New Mexico.

The Pacific Slope Branch will hold its annual meeting at the University of Nevada, Reno, Nevada, June 22 to 24 inclusive.

Beginning in January, 1927, the Monthly Bulletin of the California State Department of Agriculture resumed publication, after being temporarily suspended in June 1923.

Mr. W. Downes of the Victoria, B. C., laboratory gave an address on "Insect Conditions in British Columbia," before members of the Entomologists Group at Ottawa on January 28.

Mr. Walter Carter, in charge of investigations on the sugar beet leafhopper, located at Toppenish, Wash., visited the Alfalfa Weevil Laboratory at Salt Lake City on December 15.

Mr. E. J. Newcomer, Associate Entomologist, in charge of the Bureau of Entomology field station at Yakima, Wash., attended the spray residue conference held at Salt Lake City, Utah, February 21–22.

Mr. Joseph C. Chamberlin, Assistant Entomologist at the Citrus substation, Riverside, Calif., has resigned to accept a teaching position in the Department of Biology of the San José State Teachers College.

Weevil infestations have been found in cotton of the 1926 crop at or near the following points in Arizona: Sahuarita, Continental, Tubac, Nogales, Bowie, San Simon, Willcox, Light, McNeal, and Elfrida.

Mr. A. G. Fuller has been appointed as temporary insect pest investigator at Vancouver, B. C., to inspect shipments of nursery stock and plant products entering Canada through that port. His work will be under the general supervision of Mr. W. H. Lyne, Chief Provincial Inspector at Vancouver.

Mr. E. P. Venables, Vernon, B. C. laboratory, visited Spokane, Wash., early in December, to attend a conference on oil sprays. As a result of this conference it is planned to develop cooperative tests, etc., during 1927, in various fruitgrowing districts in British Columbia, Washington and Oregon.

Messrs. J. C. Hamlin and W. D. Reed, of Fresno, Calif., in the early part of November fumigated more than half a million dollars' worth of dried fruits with sulphur dioxide, carbon disulphide, and hydrocyanic-acid gas. These were practical fumigations on a large scale and gave valuable results.

Dr. Olive Swezy has been appointed agent of the Bureau of Entomology in cooperation with the California Experiment Station at Berkeley, Calif., to work with Dr. H. H. Severin in studying the nature of the virus which causes curly-top of sugar beets, and is transmitted to the beets by the sugar-beet leafhopper.

Messrs. E. J. Newcomer and M. A. Yothers, Associate Entomologists of the Bureau of Entomology, with headquarters at Yakima, Wash., attended the annual meeting of the Washington State Horticultural Society at Wenatchee, Wash., in December. Mr. Newcomer discussed "Oil Sprays," and Mr. Yothers presented a paper on "Codling Moth Trap Baits as a Supplementary Control Measure."

Mr. Yothers was called to Hood River, Oregon, January 10, where he addressed the fruit growers of that section on the use of trap baits in controlling the codling moth. On February 12 he visited Kennewick, Wash., where he discussed the same matter, and on the same day he returned to Yakima, where he repeated his discussion.

During October, Dr. E. A. Back of the Bureau of Entomology visited California to consult with Bureau specialists working with stored-product insects. On the way out and while he was on the Coast he inspected some work of private firms of interest to the Bureau. Of especial interest were the heat and fumigating rooms constructed for the treatment of furniture, and the work of firms actively engaged in moth-proofing fabrics.

The third meeting of the Entomological Club of Southern California was held at Alhambra on March 11, with an attendance of more than 50. The morning was spent in a discussion of methods of determining the degree of insect infestation, with particular reference to citrus scale insects and codling moth. In the afternoon the two new Department of Agriculture corn borer films were shown, and Mr. George P. Weldon gave a talk on "Education in Economic Entomology." Although less than a year old, the club membership now exceeds a hundred. There will be future meetings of the Club on June 10, September 9 and December 9, at Alhambra, Calif. All visiting entomologists are welcome.

Notes on Medical Entomology

Dr. William A. Hoffman of the School of Tropical Medicine at San Juan, P. R., spent a few days in the Division of Insects, U. S. National Museum, studying the biting gnats of the genus Culicoides and related forms.

As a result of an organized campaign of trapping the screw worm fly carried out by County Agent W. R. Nisbet and some twelve ranchmen over a large area in Menard County last year, widespread interest in the matter of controlling the screw worm fly by systematic trapping, as outlined by the United States Bureau of Entomology, has been manifested. A meeting of livestock raisers was held in Menard on February 24, at which representatives of other livestock-raising districts were present. Screw worm control was discussed by F. C. Bishopp and O. G. Babcock of the Bureau of Entomology, and the results of the local organization were presented by Mr. Nisbet. Figures of last year showed that in parts of the county where trapping was not carried out, about eight per cent of the livestock was infested by screw worms, while in the district where trapping was done the number of infested animals was reduced to less than one per cent. Following this meeting the ranchmen began the organization of several fly-trapping areas.

Errata

Page 16, line 21, for quality, read quantity